The atom, unrecognized for millenniums because of its well-nigh incredible smallness, is the world's greatest natural resource. From its exterior shells we have an infinite supply of electrons, those electrical jitterbugs that make it possible to see through the dark and beyond the horizon, listen around the world, and solve mathematical problems that would baffle all the world's unaided brains. From the interior nucleus of the atom we have energy so fantastically concentrated that it is frightening.—From Energy Unlimited *by* HARRY M. DAVIS.

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THE USE OF ANIMALS IN SCIENCE UNITS FOR FIFTH GRADE PUPILS

FAYE GRANT*
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Many science teachers believe that the production of deficiency symptoms in animals is an unsuitable experience for elementary school children. The literature, however, abounds with suggestions for units in biological science in which children are made aware of the fundamentals of nutrition by placing animals on diets deficient in one or more of the essential nutrients. In this type of experiment, litter mates receiving complete diets usually serve as controls which emphasize the difference between the incomplete and complete intakes. Pupils are said to be interested in these experiments.

In this paper some observations will be described which suggest that the depletion type of study would not be acceptable to all groups of fifth grade pupils. Based upon these observations the suggestion is made that this age group may make their own decisions as to the procedures they wish to carry out with animals in the classroom. These decisions may result in the getting of as much useful information and the making of as many pertinent observations as the planned depletion study.

A study was undertaken recently at the Laboratory School of the University of Chicago in which a unit in nutrition was introduced into the general science curriculum of fifth grade children. At the beginning of the study one pair of weanling hamsters was obtained for each of the four sections of the fifth grade. The writer, who had a part in the study, and who had not worked before with this age-group, suggested that at least one pair of the animals be

* A report of part of the work done in fulfillment for the degree of Master of Science, Division of Biological Sciences, Department of Home Economics, University of Chicago.

placed on an inadequate diet for a period sufficiently long for deficiency symptoms to develop, after which they would be returned to the normal diet of the other pairs. The science teachers, in charge of the unit, did not believe this would be a suitable procedure.[1] Consequently the plan was altered and the more positive approach described herein was used. The observations made during the study are evidence for the validity of the opinions of the experienced teachers.

Throughout the unit of instruction films illustrating the principles of nutrition were shown. Animals whose diets had been deficient in certain substances appeared frequently in these films. And while nearly all of the children were interested in the activities of the unit, and from all indications enjoyed the films and subsequent discussions, their attitude toward the pictures of animals whose growth had been stunted and whose coats had been lost, and the like, was one of disapproval. Their exclamations were those of pity or repugnance.

Even those children most eager to discuss the possible effects of nutritional deficiencies were among the most voluble in their protests against the practice as applied to animals. On one occasion, a pupil, the child of a biological scientist, demonstrated her attitude dramatically by throwing her arms over one of the cages saying, "Promise me, promise, Miss Blank, that you will not let these animals be deprived of anything for an experiment."

The development or the continuation of an attitude which might be termed mawkish, was not an objective of this study. Rather a concomitant objective was the development of an understanding and an appreciation of the methods of science. Thus an effort was made throughout to dispel the existing attitude of these pupils toward the use of animals in experimental studies. It was pointed out that research workers are not cruel, and that they, too, are usually fond of animals. Emphasis was placed on the fact that an animal may lose weight, a portion of its coat and become less active without pain.

Discussions were developed around the great role of experimental animals in furthering scientific knowledge. Lastly, it was suggested that some experimental animals may have a better chance of surviving than those in the wild state. After a time there were fewer protests when the subject was discussed. However, there was no real evidence that their attitudes had been changed.

Does this attitude mean that animals serve no useful purpose in a unit of elementary science? An affirmative answer to this question could not be given from the results of the study described here. Rather, the writer has become convinced that while all fifth grade children are not emotionally prepared to accept some of the methods

---

[1] Miss Bertha Parker and Miss Illa Podendorf of the University of Chicago.

of science which older children readily accept, they all enjoy and are benefited by the use of animals in other ways.

In view of the place of the hamsters in the procedure of the unit, it may be of use to describe more specifically a few activities developed around them.[2] On the day before the animals arrived the teachers directed discussions around the fact that animals need a good diet in order to grow at a normal rate. On the day the animals first were placed in the classrooms, the children in three of the four sections suggested that the suitableness of the food provided could be determined by weighing the animals weekly. Weighing the animals, then, became one of the first activities of the unit.

Since the hamster is a small animal weighing only 25–30 gr. when weaned a gram scale was used to determine the weights. The gram was a new unit of weight for these children and the scale a new measuring device. Thus the children were introduced to the metric system and learned as well to use the scale. The use of the scale included counterbalancing the beakers in which the animals were weighed with pans of shot.

The making of a graph, as a means of recording data, was a new experience also. The children in each group followed the graphic records of weight gained throughout the period of instruction with interest and enthusiasm.

The food mixture provided for the hamsters was a means of introducing the principles of an adequate diet. Jars containing each food which was a part of the mixture were displayed. The contents of the various jars were written on the blackboard. Appropriate amount of each food were then weighed and placed in a large jar where they were mixed. The proportion of each food was given as a percentage of the total mixture. This made necessary a discussion of the use of percentages. The percentage of each food in the mixture was then changed to a fractional part of the mixture. This, too, was written upon the blackboard. The children were requested to make a copy of this information for further use. On subsequent days the contributions of each food were discussed. The children then developed a table which they termed "Our Hamsters' Food." Table 1 is an example of the tables made by the children.

When the subject of energy and calories was presented for the first time, the children turned quite naturally to the hamsters to make a point in the discussion. They compared the energy needs of the more active animals with those of the less active. Some of the group suggested the possibility that the less active animals were not receiving enough of some substance necessary for a good appetite.

[2] Information concerning the hamster may be obtained from the "Free Turtox Service, Leaflet on the Golden Hamster," Turtox Company, 761 East 69 Place, Chicago, Illinois.

And so it went with, "I agree with that opinion" or "I disagree with that opinion," coming from all over the room.

As the animals reached sexual maturity the children voted upon whether to mate their animals or not. There was no misgiving as to the minority as each child voted to mate the animals. Then the consideration of providing suitable food for reproduction and lactation confronted them. One group voluntarily decided to increase the quantity of dried milk in the food mixture as a means of providing more calcium. Another group decided not to trust to intestinal synthesis of vitamin C, but to add greens regularly to provide this substance.

TABLE 1. OUR HAMSTERS' FOOD

Food	Amount	The Vitamin Provided	Contains Also
Whole wheat	½	B_1 or thiamine B_2 or riboflavin	Carbohydrate Protein Fat (oil) Minerals
Whole milk powder	¼–½	A D B-vitamins	Everything else needed except iron
Wheat germ	1/10	B-vitamins	Protein Fat (oil) Minerals
Yeast powder	1/10	B-vitamins	Protein
Alfalfa meal	1/20	A C	Carbohydrate Protein Minerals
Cod liver oil	20 drops	A D	Fat (oil)
Salt	few grains	—	Minerals

One event happened in connection with the mating of the hamsters which was near a tragedy in the eyes of one of the sections. As is known, many animals which reproduce prolifically often destroy their young. In order to prevent this from occurring with the hamster, it is necessary to take certain precautions such as placing the cage in a quiet, dark place a few days before delivery. However, one of the females delivered her young before these preparations had been made. The entire litter was lost. This was a difficult thing for the children as they had made extensive plans for their young animals. It was feared that this happening would decrease their interest in the unit.

Fortunately this did not happen. Due to the ingenuity of the teachers they became interested in this event as a demonstration of the way in which a balance in nature is maintained.

During the unit the group demonstrated that they could apply the principles of nutrition learned through feeding the hamsters to another species. A young mouse, apparently nearly starved or injured, was caught and brought to one of the sections. The children voted to keep it in order to restore it to health. They pointed out that it was plain to see that it needed food, but of course a very simple and complete food such as milk for a few days, then later some of the hamsters' mixture. The mouse recovered sufficiently under this regimen to escape.

At the close of the period of instruction the children gave an "open house" at which they demonstrated for their parents and friends some of the scientific activities which had interested them during the year. Some chose to demonstrate experiments related to other units, but others chose certain other experiments which had been a part of the unit in nutrition. Many of them chose to display and explain the function of each food component which was a part of the hamsters' diet, while others explained the graphs which recorded the gains in weight made by the animals. One boy gave a short account of the use of the hamster in this country.

At this time several mothers commented that they felt that no other unit of the year had contributed as much to their children as this one which included the feeding and mating of the hamsters.

Perhaps it may be said then that the learning which resulted from the daily care and feeding, the weekly weighing and recording of the weight gained, and the mating of the animals was not equalled by a combination of all the other activities of the unit. The hamsters were not only the center of interest throughout the unit, but the basis for many lessons as well.

Other topics, of course, were considered in the unit. In addition to the activities developed around the hamsters, discussions and activities included the following topics:

1. Food Habits and Customs
2. Carbohydrate, Fats, and Proteins
3. Vitamins and Minerals
4. Food Tests
5. The Body's Needs for Energy
6. The "Good" Lunch
7. The Composition of Milk
8. Food Facts and Fancies
9. Eating a Picnic Lunch

However, as suggested above, it was the use of the animals which

made these lessons significant to the pupils. To have commenced the unit with topics related to their personal needs would probably have been an old story to them. But since these children were exceedingly fond of animals, as most children seem to be, their interest in procedures that resulted in healthy pets was high from the first. After their experience with the animals it was easy for them to transfer their interest to considerations of their own needs.

The results of this study suggest that animals are useful in many ways in the elementary science unit. The field is broad and any one of the possible ways which have been noted here, as well as many others motivate the children in worthwhile learning activities.

ADAM TO ATOM

KENNETH E. ANDERSON

Since the dawn of history, man has attempted to push back the veil that hides the key to knowledge. Since the time of Adam, man has spread himself over the earth into tribes, clans, and nations. Since the time of Adam, man has used the tools and products of science to improve his living or as weapons to fight the neighboring clan or nation.

Early man, when confronted with a problem, often used pieces of stone to build a fireplace on which to cook his meal; or when confronted with danger chose the nearest stone to use as a weapon. Science can explain the formation of the stone on the basis of wind and water erosion, or by the freezing of water and the subsequent expansion. Science is also able to tell us the chemical composition of the stone, and classify it as sandstone, granite, or marble.

Science is simply an explanation of what is. Science infers no good or evil. A stone may be used as a fireplace or as a weapon with which to kill. Science does not determine the use to which man may put the stone. Only man can determine whether the use will be of benefit to mankind.

The past few years have witnessed an acceleration in the products of science, such as the atom bomb. Even though the atom bomb possesses terrific potentialities as a weapon of war as compared to a stone, the fact remains that both may be used as weapons of war or for the benefit of mankind. Science has contributed many weapons of war, but war is not the sole responsibility of science. That responsibility rests on every citizen. Science is neither good nor bad—it is what man does with science or its products that may be good or bad.

Some may call this an age of gadgets produced by science, but one of the chief contributions of science has been a method of thought superior to none—the scientific method. If the method of science were applied to the problems confronting man in world politics, education, and leadership, man would be able to use the products of science to improve social and economic progress. We need only quote Benjamin Franklin to substantiate the above statement: "The rapid progress true science now makes, occasions my regretting that I was born so soon. It is impossible to imagine the height to which may be carried, in a thousand years, the power of man over matter. O that moral science were in a fair way of improvement, that men would cease to be wolves to one another, and that human beings would at length learn what they now improperly call humanity."

Yes, man has progressed from Adam to atom. Shall it be from Adam to atom to peace? Shall it be from Adam to atom to chaos? Only man can determine the direction we now take.

HEAT PRODUCTION IN A CURRENT-CARRYING WIRE

FRED W. SCHUELER
State University of Iowa, Iowa City, Iowa

PART I—DESCRIPTIVE

Any elementary theory of electrical conduction must clarify at least the following two points.

1. It must give a clear mechanistic picture of the way in which electrons are transferred through a wire during the process of electrical conduction.
2. It must explain just how the transference of these electrons results in molecular motion or heat.

In order to explain the first of these points it has been customary to draw upon the fact that metals are characterized chemically by a tendency to lose electrons, i.e., the electrons in the outermost shell of metals are lost and gained very easily. Keeping in mind this fundamental property of metals, it is only necessary to show how the actual flow of electrons takes place when a current is passed through the wire and how this mechanism results in the formation of heat. Thus, consider two consecutive metal molecules arranged within the boundaries of a wire as in Fig. 1a. When an electrical battery is attached to the ends of the wire this is equivalent to the establishment of an electrical potential with respect to the two given molecules in the wire as in Fig. 1b. Now, by means of electrical induction one may consider a rearrangement of the charges (electrons) within the molecules to give the succeeding arrangement shown in Fig. 1c. This unequal distribution of charges will be accompanied by a displacement of the molecules (see Fig. 1d) to give the position shown in Fig. 1e. Discharge of electrons then takes place (see Fig. 1f). The resulting molecules are charged as in Fig. 1g. The molecules now being opposite in charge are attracted to one another (as well as being repelled by the circuit boundaries) to result in the displacement shown in Fig. 1h and the new arrangement (Fig. 1i) is attained. Again an electron transfer takes place (Fig. 1j) and the displacement cycle is completed and ready to repeat itself (Fig. 1k). Such a shifting of molecules back and forth in the wire constitutes molecular motion or heat. Furthermore, the greater the number of electrons to be transferred per second (i.e., the greater the current or amperage) the higher the temperature of the wire, for the greater must be the velocity of the molecules to transfer the electrons. Such an arrangement also explains the conductivity of metals at various temperatures. Thus, it

is obvious that the closer are the molecules in the wire, the shorter will be their oscillations in conveying the electrons and thus the less their velocity and kinetic energy, the lower the temperature of the wire. Also, since the molecules will be closer together the lower is the temperature, it is clear that conduction will take place with greater and greater ease as the temperature is lowered until, at a certain point, (about absolute zero) when the molecules are "touching" one another, no molecular motion (work) will be required for the transference of electrons and the wire becomes a perfect conductor. This idea agrees with the results obtained upon the measurement of

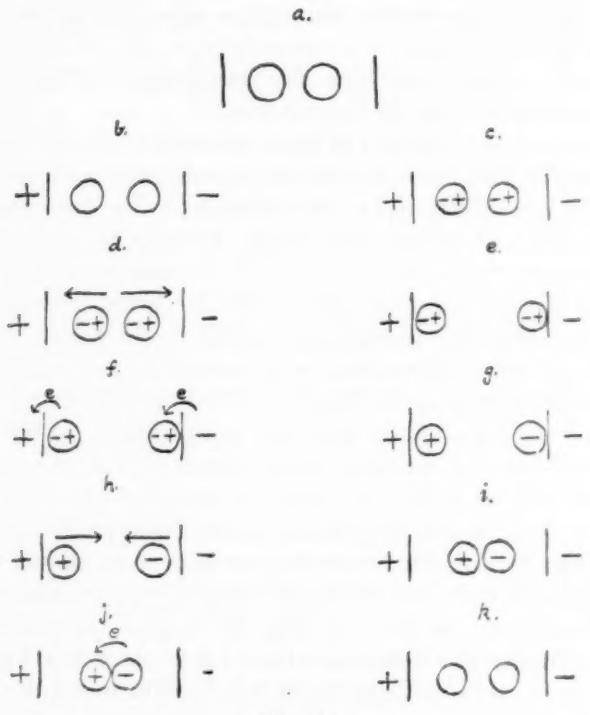


FIG. 1

the conductivity of metals at the temperature of liquid helium (2) in which some metals besome perfect conductors, i.e., a current continues to flow through them even after the current source is turned off. This simple theory also suggests an explanation of the "skin effect," the phenomenon which is exhibited when a current of high frequency travels only on the surface of a conductor. For it is clear that when a direct current is passing through a wire the molecules of the wire will vibrate at a particular rate which depends only upon the current density and the intermolecular (or atomic) distance. This

means that in a wire bearing a direct current the actual rate of oscillation of the molecules will depend upon the natural rate of vibration of the molecules as determined by the crystal lattice forces. If, however, a high frequency current is passed through the wire, the natural oscillation of the wire molecules will ordinarily not be in phase with the high frequency current. Therefore, the high frequency current will tend to travel in that portion of the wire which least hinders its passage, the surface of the wire; for the molecules in the surface of the wire are not held as rigidly (because there are not as many intermolecular force bonds) as the molecules in the interior of the wire (see Fig. 2) and therefore adapt their vibration more easily to the frequency of the current, since they are freer to move.

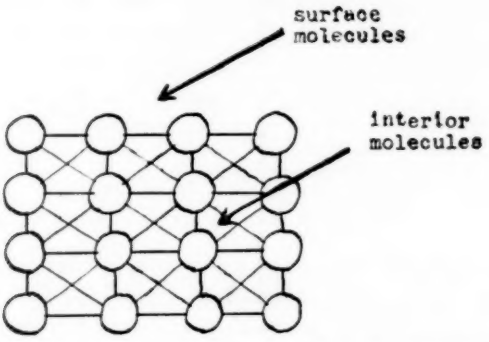


FIG. 2. The lines represent intermolecular force bonds between the molecules.

The above discussion concludes the descriptive part of this paper and the remaining space will be devoted to the development of some simple equations to relate the temperature of metal wires to the current density and the resistance and to verify the simple theory which has been outlined.

PART II—MATHEMATICAL

In order to determine the temperature of an electrically conducting wire it is first necessary to calculate the velocity of the molecules within the wire.

Then, from the formulae

$$K.E. = \tfrac{1}{2}mv^2$$

$K.E.$ = kinetic energy
m = mass
v = velocity

and

$$T = K[K.E.]$$

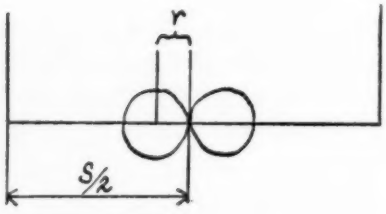
T = absolute temperature
K = proportionality constant

one may determine the absolute temperature of the wire.

Suppose that the number of electrons to be transferred per second through a cross sectional area of the wire is n. Further, allow N to represent the number of molecules in the area cross section (1 molecule thick). Then, the number of electrons to be transferred by each molecule in the cross section (and therefore in the whole wire if it is of uniform cross section), is n/N. Consider the distance that each molecule must move during a single displacement cycle, one displacement cycle delivering one or more electrons. According to Diagram 1 it is assumed that the molecules may move until they "touch" one another. (See Diagram 2.) Then, the distance moved by a single molecule during an entire displacement cycle, as described in Part I, will be,

s = internuclear distance

DIAGRAM 1



r = molecular radius

DIAGRAM 2

$$4\left(\frac{s}{2}-r\right).$$

Assume next that the number of electrons transferred by a molecule on the average during a displacement cycle is (P) so that the number of complete displacement cycles per second (the frequency) required by each molecule will be n/PN. And, since frequency times distance equals velocity (V), the average velocity of the molecule will be,

$$v = 4\left(\frac{s}{2} - r\right)\cdot\frac{n}{PN}.$$

The average kinetic energy ($k.e.$) will be,

$$k.e. = \tfrac{1}{2}mv^2 = \frac{m}{2}\left[4\left(\frac{s}{2} - r\right)\cdot\frac{n}{PN}\right]^2$$

where (m) equals the mass of the molecule. Assuming that the fraction of the total kinetic energy contributed from sources other than the flow of electrons is a constant ($8C$), since the wire is in thermal equilibrium with its environment, the kinetic energy ($k.e'$) of the molecules in the wire will be,

$$k.e.' = 8m\left[\left(\frac{s}{2}\frac{n}{} - r\right)\cdot\frac{n}{PN}\right]^2 + 8C.$$

Now, the rate at which heat is lost from the wire by radiation is approximately proportional to the difference between the temperature of the wire and the temperature of the environment as given by Newton's laws of cooling (3). That is, the heat lost in absolute temperature (γ) due to radiation is given by,

$$\gamma = 8k(T - T_0)$$

$8k$ = proportionality constant
T = actual temperature
T_0 = temperature of the environment

and, the actual kinetic energy ($K.E.$) giving the temperature of the wire at any time is,

$$K.E. = 8m\left[\left(\frac{s}{2} - r\right)\cdot\frac{n}{PN}\right]^2 - 8k(T - T_0) + 8C$$

and the temperature is,

$$T = \frac{K}{8}\,[K.E.] = K\left\{m\left[\left(\frac{s}{2} - r\right)\cdot\frac{n}{PN}\right]^2 - k(T - T_0) + C\right\}$$

$$\frac{K}{8} = \text{proportionality constant.}$$

Solving this equation so that (T) is given explicitly, one gets,

$$\text{I} \qquad T=\frac{Km\left[\left(\frac{s}{2}-r\right)\cdot\frac{n}{PN}\right]^2+kKT_0+KC}{(1+kK)}.$$

If the given wire is a pure element having an atomic weight m, and if the length of a given mass M of the wire is L, then the number of molecules (atoms) in a unit length of the wire will be,

$$\frac{M\times 6.023\times 10^{23}}{L\times m}.$$

and the number of molecules in a cross sectional area one molecule thick ($2r$), will be,

$$N=\frac{2r\times M\times 6.023\times 10^{23}}{L\times m}.$$

This quantity may be substituted for (N) in Formula I. Furthermore, if the number of amperes flowing is (a) and since one ampere will deposit .001118 gram of pure silver per second or

$$\frac{.001118}{108}\text{ gram atoms}\left(\text{equal to }\frac{.001118}{108}\times 6.023\times 10^{23}\right)$$

of silver, and since silver is monovalent, the number of electrons equivalent to an amperage (a) is,

$$\frac{.001118\times 6.023\times 10^{23}\times a}{108}.$$

This is the same as the number (n) of electrons to be transported through a cross sectional area of the wire per second; therefore,

$$n=\frac{.001118\times 6.023\times 10^{23}\times a}{108}.$$

And this expression may be substituted into Formula I for (n).

A further effect which must be taken into account is that the internuclear distance (S) is proportional to the absolute temperature.

$$s=2\beta T \qquad 2\beta=\text{proportionality constant.}$$

Substituting $s=2\beta T$ gives,

$$\text{II} \qquad T=\frac{Km\left[(\beta T-r)\cdot\frac{n}{PN}\right]^2+(kKT_0+KC)}{(1+kK)}.$$

Then upon substituting into Formula II the expressions for (n) and (N) one gets Formula III.

$$\text{III} \qquad T=\frac{Km\left[(\beta T-r)\cdot\frac{.001118aLm}{P\cdot 216\cdot rM}\right]^2+K(kT_0+C)}{(1+kK)}.$$

Formula III could be solved explicitly for (T) in terms of the amperage (a) but it is more convenient in testing these expressions against experimental data to obtain (T) in terms of the resistance (R) of the wire. In this way one may test the reliability of the formulae against known temperature-resistance data which are readily obtainable. Therefore, making the assumption that for a given potential the number of electrons flowing per second is inversely proportional to a linear function of the resistance, one writes,

$$n=\frac{k_1}{R+k_2} \qquad k_1 \text{ and } k_2 \text{ are constants.}$$

And, upon substituting this quantity for (n) in Formula II one obtains the expression,

$$T=\frac{Km\left[(\beta T-r)\cdot\frac{k_1}{(R+k_2)\cdot p\cdot N}\right]^2+K(kT_0+C)}{(1+kK)}.$$

Substitute now the constants

$$A=\frac{K}{(1+kK)}$$

$$B=\frac{K(kT_0+C)}{(1+kK)}$$

to get,

$$T=Am\left[(\beta T-r)\cdot\frac{k_1}{(R+k^2)\cdot p\cdot N}\right]^2+B.$$

This equation may be solved for (R) explicitly.

$$\text{IV} \qquad R=k_1\sqrt{Am}\,\frac{(\beta T-r)}{\sqrt{P^2N^2T-P^2N^2B}}-k_2.$$

Formula IV may be applied directly to the representation of experimental temperature-resistance data as illustrated by the following example.

This example will apply Formula IV to the representation of temperature-resistance data for pure silver.

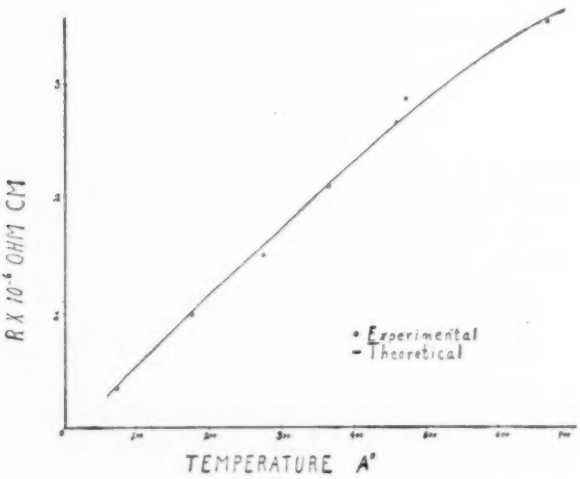
First, make the plausible assumption that the number of electrons transferred per displacement cycle per atom will be one, i.e., $P=1$, since silver has a valence of one. Also, since (N) the number of atoms in a cross sectional area is constant and the atomic weight (m) will be constant, Formula IV becomes,

$$\text{V} \qquad R=k_3\frac{(\beta T-r)}{\sqrt{k_4T+k_5}}-k^2 \begin{cases} k_3=k_1\sqrt{A\,m} \\ k_4=P^2N^2 \\ k_5=-P^2N^2B. \end{cases}$$

The constants k_2, k_3, k_4, k_5, and β must be evaluated from known data. The constant (r) equal to the atomic radius of silver is given as 1.13 (4) although this could also be evaluated from the data. The following was taken from the *Handbook of Chemistry and Physics* (5):

TEMPERATURE-RESISTANCE TABLE

$t°$ C.	$T°$ A	$R\times10^{-6}$ ohm cm.
0	273	1.468
98.15	371.15	2.062
192.1	465.1	2.608
−258.6	14.4	.009
−200	73	.357
−100	173	.916
100	373	2.15
200	473	2.80
400	673	3.46
750	1023	6.65



Applying these data to the evaluation of the above constants one obtains the equation,

$$\text{VI} \qquad R = 2.47\left[\frac{.083T - 1.13}{\sqrt{1.365T - 18.1}}\right] - 1.1.$$

The comparison of the resulting Formula VI with the plotted data is shown in the graph.

An interesting result may be derived from Formula VI. One sees that for a certain value of T the demominator and numerator will vanish; this value is the same in both cases and is equal to about 13.5. Since Formula VI ceases to represent the resistance of the wire at this point, becoming imaginary for $t < 13.5$, one might speculate that this is the theoretical temperature at which silver should become a super conductor.

Formulae I, II, III, contain such quantities as the atomic radius (r), (m) the atomic weight, and (S) the internuclear distance, all of which might be calculated from temperature-resistance data alone.

Further applications would possibly be the generalization of this simple theory to a quantitative treatment of high frequency currents and the skin effect.

References

1. Wilson, A. H., *The Theory of Metals*, Cambridge, University Press, 1936, pp. 190–233.
2. Wilson, A. H., *ibid.*, pp. 234–243.
3. Kimball, Arthur L., *College Physics*, New York: Henry Holt and Co., 1937, p. 289.
4. Glasstone, Samuel, *Text-book of Physical Chemistry*, New York: D. Van Nostrand Co., Inc., 1943, p. 375.
5. *Handbook of Chemistry and Physics*, ed. by Charles D. Hodgman, Cleveland, Ohio: Chemical Rubber Publishing Co., 1943, p. 1872.

NEW G-E TABLE MODEL RADIO FOR SCHOOLS

In response to demands from educational leaders and dealers in major markets, a high quality FM-AM table model receiver has been designed by the General Electric Company, and is ready for immediate distribution, according to E. P. Toal, sales manager of standard line radios at Electronics Park here.

Using eight tubes plus one rectifier, Model X-415 also incorporates two short-wave bands and is one of the sturdiest receivers yet to be offered on the domestic market, Mr. Toal said. The list price will be $189.95.

Among its special features are the new Guillotine Tuner for high gain, stabilized tuning on FM and short-wave bands; a built-in antenna for near-by FM stations; an eight-inch Superdynapower speaker with sufficient power for group listening, and push-button tuning. The modernistically designed cabinet is built to withstand hard usage.

"For some time we have been requested by educational leaders, distributors and dealers to produce a table model FM-AM radio for school use," Mr. Toal said. "Many cities have FM stations devoted to educational broadcasting. This receiver is ideal for tuning in these stations."

SELECTED REFERENCES FOR HIGH SCHOOL PHYSICS*

G. P. CAHOON
Ohio State University, Columbus, Ohio

This list does not purport to include "the" best books for high school physics. There are scores of other excellent books, some of which many will feel should have been included—and there may be some books in this list which should not be included. Obviously "best" for one teacher and for a particular group of students is not necessarily best for another teacher or another student group in a different situation, with different backgrounds, needs, interests, and purposes.

There are many factors which do and should enter into the selection of a classroom reference shelf. These also, of course, vary for different situations. One obvious factor is that of cost. The present list would amount to an outlay of over two hundred dollars. While this would be more than many, if not most schools, could manage at one time, the assumption was made that few schools would be so influenced by this selection that they would order the complete list. Since some teachers would be interested in suitable books in one area of physics and some in another, however, it seemed desirable that a few books in each area should be included, which accounts for the extent of the list.

In selecting a final list of 75–80 from an original list of over 250, some criteria had to be utilized. The following were selected. The books selected should:

1. Be primarily for student use in classroom, laboratory, and outside work, rather than for teacher reference.
2. Be recent and up-to-date, unless older books are more suitable.
3. Be within the range of the level of reading ability and understanding of typical high school students.
4. Provide for a wide variety of needs, interests, and backgrounds of students.
5. Include only books—not pamphlets, magazines, or mimeographed materials.
6. Include books from the usual publishing houses—not from government agencies, or industrial firms.
7. Include books published only in the United States.
8. Not be excluded because of price alone.
9. Be interestingly written and well illustrated.
10. Be concerned with physics primarily—not general books on science with some physics included.
11. Not include high school or college texts, unless these contain

* Presented at the Physics Section of the Central Association of Science and Mathematics Teachers, November 28, 1947.

some important or unique feature not in others.

12. Be in some way better for secondary school use than others having similar content.
13. Have been used or at least critically examined by the compiler of this list.

The extent to which the final list really meets these criteria may be quite inadequate. Certainly the compiler has felt inadequate and confused as he looked over lists of hundreds of titles, read scores of reviews and examined over 200 physics books—so much so that he now calls for help.

Assuming that it is desirable to bring out a "yearly model" of such a list, with all the "bugs" of the previous years' models ironed out and any desirable new features and items added, will you please send me for the 1948 edition any or all of the following:

1. Titles of any new books which you think should be included in the list. Include author, title, publisher, (with address if it is not well known) and date of publication and price if possible. Give a brief statement of the book's unique feature or outstanding characteristics or why you think it should be included.
2. Titles in the present list which you think should be omitted or replaced by others—with a brief statement of the reasons.
3. Additions or deletions in the list of criteria.
4. Suggestions for changes in the groupings or areas.
5. Suggestions for any other feature which should be included or modification which should be made.

Among the limitations of the present list are the small number of suitable recent books on heating, ventilation, refrigeration, lighting, color, sound, music, and acoustics. Should books on "vocations" in physics be included? Are there other better (more suitable) books on photography or machines than those included? Is there a better heading for the books in the category called "general"? These are some of the kinds of help which would be appreciated.

The present list is arranged alphabetically by author under the following areas as headings: Astronomy, Atoms, Automobile, Aviation, Biography-History, Electricity, General, Heat, Light-Color-Photography, Mechanics, Meteorology, Radio-Electronics, Relativity, Sound-Music.

Astronomy

Abbott, C. G., *The Earth and the Stars.* D. Van Nostrand, 1946, 258 p., $3.75.

Allen, John S. *Astronomy—What Everyone Should Know.* Bobbs-Merrill, 1945, 199 p., $2.50.

Ingalls, A. G. (ed.) *Amateur Telescope Making.* Scientific American Publishing Company, 1943, 500 p., $5.00.

Skilling, W. T., and Richardson, R. S. *Sun, Moon, and Stars.* McGraw-Hill, 1946, 275 p., $2.50.

Atoms

Eidinoff, M. L. and Ruchlis, Hyman. *Atomics for the Millions.* McGraw-Hill, 1947, 281 p., $3.50.

Frisch, O. R. *Meet the Atoms.* A. A. Wyn, Inc., 1947, 226 p., $3.00.

Gamow, George. *Atomic Energy in Cosmic and Human Life.* Macmillan, 1947, 161 p., $3.00.

Hecht, Selig. *Explaining the Atom.* Viking, 1947, 205 p., $2.75.

Millikan, Robert A. *Electrons, Protons, Photons, Neutrons, Mesotrons, and Cosmic Rays.* University of Chicago Press, 1947, 642 p., $6.00.

Solomon, Arthur K. *Why Smash Atoms?* Harvard University Press, 1946, 204 p., $3.00.

Automobile

Crouse, William H. *Everyday Automobile Repairs.* McGraw-Hill, 1946, 296 p., $2.50.

Dykes, A. L. *Automobile and Gasoline Engine Encyclopedia.* Goodheart-Willcox, Chicago, 1943, 1244 p.+112 p., 20th ed., $6.00.

Kuns, Ray F. *Automotive Essentials.* Bruce Publishing Company, 1941, 436 p., $3.00.

Steele, Jack. *How to Tune up Your Automobile.* Norman W. Henley, 1947, 229 p., $2.00.

Aviation

Aviation Education Research Group. *Science of Pre-Flight Aeronautics for High Schools.* Macmillan, 1942, $1.25.

Christofferson, H. C., and others. *Demonstrations and Laboratory Experiments in the Science of Aeronautics.* McGraw-Hill, 1945, 155 p., $2.00.

Ley, Willy. *Rockets.* Viking, 1945, $3.50.

Manzer, James Gordon; Peake, M. M.; and Leps, J. M. *Physical Science in the Air Age.* Macmillan, 1942, 198 p., $.80.

Pendray, G. E. *The Coming Age of Rocket Power.* Harper and Bros., 1945, 244 p., $3.50.

Biography-History

Chase, Carl T. *The Evolution of Modern Physics.* D. Van Nostrand, 1947, 203 p., $2.50.

Sedgwick, W. T.: Tyler, H. W.; and Bigelow, R. P. *A Short History of Science.* Macmillan, 1939, 512 p., $3.75.

Electricity

Beauchamp, W. L. and Mayfield, J. C. *Basic Electricity.* Scott, Foresman and Company, 1943, 312 p., $1.80.

Hector, L. G., Lein, H. S., and Scouten, C. E. *Electronic Physics.* Blakiston, 1943, 355 p., $2.50.

Lunt, Joseph R. and Wyman, William T. *Electricity for Everyone.* Macmillan, 1943, 649 p., $3.25.

Morecock, Earle M. *Direct-Current Circuits.* Harper, 1944, 387 p., $3.25.

Richter, H. P. *Practical Electrical Wiring.* McGraw-Hill, 1941, $3.00.

Yates, Raymond. *Fun with Electrons.* D. Appleton-Century, 1945, 159 p. $2.75.

General

Avery, Madaly. *Household Physics.* Macmillan, 1946, 470 p., $3.00.

Baxter, James P., 3rd. *Scientists Against Time.* Little, Brown, 1946, 473 p., $5.00.

Handbook of Chemistry and Physics. Chemical Rubber Company, Cleveland, Ohio, 30th ed., 1947, 2686 p., $5.00.

Harrison, George R. *Atoms in Action.* Garden City Publishing Company, 1944, 401 p., $1.49.

Hausrath, Alfred H. and Harms, John H. *Consumer Science.* Macmillan. 1941, 692 p., $2.20.
Huey, E. G. *What Makes the Wheels Go Round.* Reynal, 1940, 175 p., $2.50.
Lemon, Harvey B. *From Galileo to Nuclear Age.* University of Chicago Press, 1946, 451 p., $5.00.
Leyson, Burr. *It Works Like This.* Dutton, 1942, 224 p. $2.50.
Luhr, Overton. *Physics Tells Why.* The Jaques Cattrell Press, 1943, 318 p., $3.50.
Lynde, J. C. *Science Experiences with Inexpensive Equipment.* International Textbook Company, 1940, 272 p., $1.60.
Meyer, Jerome S. *The ABC of Physics.* Dial Press, 1944, 346 p., $3.50.
Radcliffe, J. D. (ed.) *Science Yearbook of 1947.* Doubleday, 1947, 247 p., $2.50.
Sutton, Richard M. *Demonstration Experiments in Physics.* McGraw-Hill, 1938, 545 p., $4.50.
Van Nostrand's Scientific Encyclopedia. D. Van Nostrand, 1947, 1600 p., $12.00.

Heat

Mott-Smith, Morton. *Heat and Its Workings.* D. Appleton Century, 1933, 240 p., $2.00.

Light—Color—Photography

Boucher, Paul E. *Fundamentals of Photography.* D. Van Nostrand, 1940, 356 p., $3.50.
Bragg, Sir William. *The Universe of Light.* The Macmillan Company, 1933, 283 p., $3.50.
Luckiesh, Matthew. *Light, Vision, and Seeing.* D. Van Nostrand, 1944, 323 p., $4.50.
Neblette, C. B. *Elementary Photography for Club and Home Use.* Macmillan, 1944, 295 p., $1.00.

Mechanics

Harrison, George Russell. *How Things Work.* Wm. Morrow and Company, 1941, 302 p., $2.75.
Morgan, Alfred. *The Boys' Book of Engines, Motors, and Turbines.* Charles Scribner's Sons, 1946, 264 p., $2.75.
Mott-Smith, Morton. *This Mechanical World.* D. Appleton-Century, 1932, 233 p., $2.00.

Meteorology

Aerology for Pilots. (Flight Preparation Training Series), McGraw-Hill, 1943, 107 p., $1.25.
Humphreys, William Jackson. *Ways of the Weather.* Jacques Cattrell Press, Lancaster, Pa., 1942, 400 p., $4.00.
Longstreth, T. M. *Knowing the Weather.* Macmillan, 1943, 150 p., $1.69.
Mudge, Robert W. *Meteorology for Pilots.* McGraw-Hill, 1945, 259 p., $3.00.

Radio-Electronics

American Radio Relay League. *The Radio Amateur's Handbook.* American Radio Relay League, West Hartford, Conn., 1946, 728 p., $1.00.
Atherton, Ralph. *Principles of Radio for Operators.* Macmillan, 1945, 344 p., $3.75.
De Forest, Lee. *Television—Today and Tomorrow.* Dial Press, 1942, 361 p., $3.75.
Dunlap, Orrin E. *Radar.* Harper, 1946, 208 p., $2.50.
Eddy, William C. *Television: The Eyes of Tomorrow.* Prentice-Hall, 1945, 330 p., $3.75.
Henney, Keith. *Principles of Radio.* Wiley, 1942, 549 p., $3.50.
Mills, John. *Electronics, Today and Tomorrow.* Van Nostrand, 1944, 178 p., $2.75.
Mooers, Calvin N. and Mooers, Charlotte D. *Electronics: What Everyone Should Know.* Bobbs-Merrill, 1947, 229 p., $2.75.

Stokley, James. *Electrons in Action.* McGraw-Hill, 1946, 320 p., $3.00.
Yates, Raymond F. *The Working Electron.* Harper, 1946, 247 p., $2.50.

Relativity

Gamow, George. *Mr. Thompkins in Wonderland.* Macmillan, 1940, 91 p., $2.00.
Reichenbach, Hans. *From Copernicus to Einstein.* Philosophical Library, Inc., 15 E. 40th St., New York, New York, 123 p., $2.00.

Sound-Music

Culver, Charles A. *Musical Acoustics.* Blakiston, 1947, 215 p., $3.50.
Jeans, Sir James. *Science and Music.* Macmillan Company, 1940, 258 p., $2.75.

(Addresses of publishers may be obtained from recent bound volumes of *Cumulative Book Index.*)

WORKSHOP FOR TEACHERS IN MATHEMATICS, SCIENCE, AVIATION

The Ohio State University, Columbus 10, Ohio
June 22–July 28, 1948

A workshop for teachers and supervisors concerned with improving the programs of mathematics, science or aviation in their own school systems is being offered by Ohio State University this summer. It has been planned particularly for teachers and administrators in junior and senior high schools, and is part of the summer session offering of the Department of Education. The workshop will be given during the first six weeks term, June 22 to July 29. Teachers with appropriate background may register in the workshop for approximately half of a full term load for graduate credit, and take other graduate or undergraduate courses for the remainder.

There will be two major types of experiences provided; individual or small-group projects, and common activities involving the group as a whole. Problems of concern to each participant will be studied in connection with the concept of a continuous program of mathematics and science from the first through the twelfth grade. Students will work on such problems as planning courses of study, working out guide sheets and tests, carrying out laboratory and field work, improvising apparatus, locating reference materials, and trying out demonstrations and visual aids. Provision has been made for first hand experiences with demonstrations, laboratory equipment, and field work in each of the areas. Common activities of the whole group include such activities as lectures, campus visitations, motion pictures, exhibits, discussion groups, off-campus trips, operation of School Link Trainer, and airplane flights.

In addition to the regular members of the workshop staff which includes Professors H. P. Fawcett, J. S. Richardson, and G. P. Cahoon, a number of visiting experts have been invited to participate. These include Dr. Philip Johnson, Specialist for Science, U. S. Office of Education, Washington, D. C.; Wm. Konicek, Link Aviation, Binghamton, New York; Horace Gilbert, Civil Aeronautics Administration, Assistant to Regional Administrator, Chicago; Roy Mertes, Director, School and College Service, United Air Lines, Chicago.

For a summer school bulletin, write to Registrar, The Ohio State University, Columbus, Ohio. For further information relating to this workshop, write G. P. Cahoon, Arps Hall, The Ohio State University, Columbus 10, Ohio.

Genius begins great works, labor alone finishes them.

—JOUBERT

WHAT ABOUT GEOGRAPHY?

JOHN STERNIG
Glencoe Public Schools, Glencoe, Illinois

The science of geography is seldom mentioned as such in our Elementary Schools these days. Children, presumably, learn the basic facts of physiography and geography in correlation with experiences in the broad field of social studies or sciences. Now, there can be no quarrel with the idea that geography is apt to be meaningless when taught apart from man, his use of, and adjustment to it. But it may be well from time to time to examine what actually happens in the social studies so far as geography is concerned.

Are children discovering the physical facts about our earth? Do they understand the causes of day and night, seasons, climate, etc. any better than we did when we went to school? We did not get it very well, as any average adult will demonstrate. Do our children know any better how to find places on maps and globes, how to use latitude and longitude? Do news reports about world events, tidal waves, hurricanes, volcanoes, long distance flights, and similar events related to geography have any more real meaning to children these days than they did to us?

Perhaps the reader, in considering the children with whom he or she deals, can honestly say yes. If so, there is cause for satisfaction; for it is quite certain that not all children are gaining the concepts and understandings in geography which they need in order to understand the events in the world about them. Schools might do well to maintain contacts with their graduates as they go through high school and college. These young folks can tell us our shortcomings, the places where we failed them. In many cases geographical understandings would stand high as gaps in their preparation. Their analysis may not always be sound nor complete, but their feelings about such matters could well form the basis for some serious self evaluation on the part of a school staff.

But to return to the area of geography. I should like to emphasize the need for teacher awareness of what the basic understandings are. We often become involved with the study of man and his activities and lose sight of the plain science concepts that somehow or other escape notice. For instance: We do quite well in correlating man's activities with the broad factors involved in night and day, seasons, climate, latitude, longitude, location and so on. But we sometimes neglect to build for understanding of these as science facts, with definite causes and effects. Somewhere it is essential that a child learn

the scientific basis of these things if he is to use more than rote memory in his dealings with them.

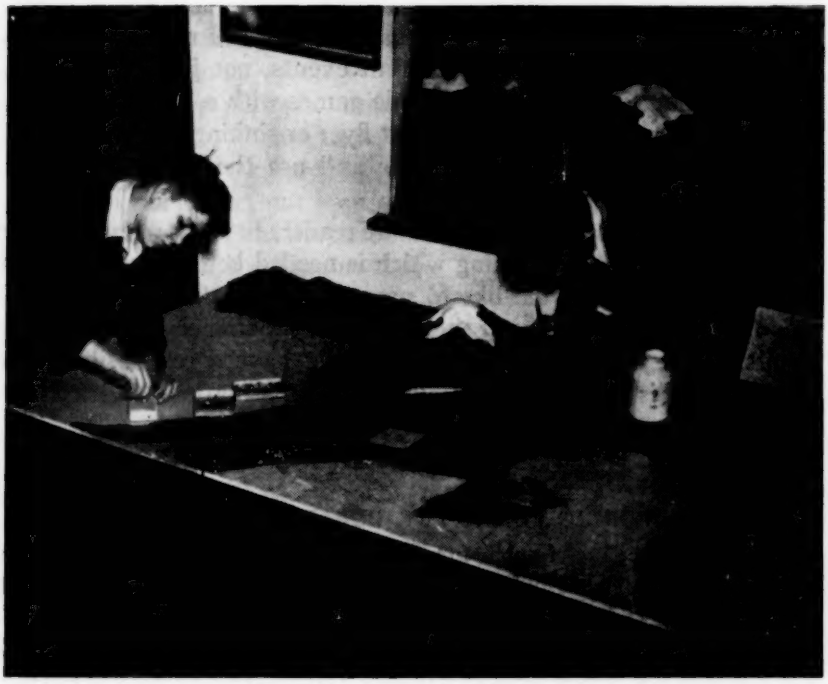
I should like to suggest a few ideas relating to our earth which an elementary school child is entitled to have before he leaves for high school.

1. Origin of our earth
2. Earth in space
    a. Earth as a sphere—relation to sun and moon
    b. Cause of day and night—rotation
    c. Cause of seasons—Inclination of axis plus revolution around sun

3. Parts of the earth
    a. Lithosphere—solid part of earth
        1. What earth is like from inside out
        2. Origin of continents
        3. Origin of soils
        4. Forces changing the earth's surface
    b. Hydrosphere—waters of the earth
        1. Origin of oceans, seas, lakes, rivers etc.
        2. Water cycle
    c. Atmosphere
        1. Origin and composition
        2. Layers of the atmosphere
        3. Weather and climate
4. Geographical concepts
    a. Hemispheres—N.S.E.W., land and water

b. Latitude
c. Longitude
d. Maps and globes etc. etc.

The above outline is not intended to be complete; only to indicate scope. Children need more than scattered bits of information. They need to see the unity and organization of facts about the earth. Naturally these points will be taught as purposefully and meaningfully as possible; always relating them to man. Furthermore, they will probably not be taught all at one time, though it is my opinion that a



review in 7th or 8th grade might well cover the full outline in a refresher course.

Of course, an outline is no guarantee that children will understand better than we did. More realistic methods of teaching are called for.

First of all, no reliance on memorized facts can be depended upon to produce understanding. Instead we need to have more experience by children in observations, study, recording, charts, models, discussions of the actual phenomena in question. For instance: Demonstrate night, day, and seasons with a globe and a light. Then discuss the whole process fully. Finally give children a chance to do it themselves until they really see the relationship of the various factors in-

volved. Keep a record, preferably pictorial, of the place of the setting sun for a full year to show its apparent movement from south to north and back again. Keep a record of the shadows cast by the noon day sun for a full year to implement the previous record. Observe the apparent star movements at night to see where the earth's pole is pointing and the effect this has on the stars. Note the change of constellations with the seasons for proof of annual revolution around the sun. Many of these observations of the real thing can be reinforced in the classroom by demonstrations with models, charts and drawings. Make a large globe of the earth, terrain models, local maps. These will help make the earth more real to the children in a geographical sense, and serve as fine tools as well. Use maps and globes constantly in connection with current events, not just for abstract drill. Make up latitude and longitude games with a large grid in the room or on the playground. Play lost flyer or sinking ship sending an S.O.S. to rescue vessels. Investigate and use the numerous audio-visual materials available in this area.

The suggestions above will stimulate readers to think of even better ones, I am sure. It is thinking which is needed before any of us improve. In closing I should like to suggest that *repetition* through real use, over a period of years of these kinds of experiences could achieve results better than those of the past. We have a responsibility to children in this area. Let's examine our own situations and see how we are doing.

PUBLIC FUNDS FOR PUBLIC SCHOOLS

Opposition to the use of public funds for parochial or private schools because it would weaken if not destroy public education was the theme of a recent address by NEA Executive Secretary Willard E. Givens at the recent state meeting of Michigan superintendents.

Secretary Givens listed seven ways in which "the basic principle of the separation of church and state is being undermined": [1] the transportation of children in public buses to parochial schools; [2] furnishing of textbooks at public expense to parochial-school children; [3] extending of public-health services to children in attendance at parochial schools; [4] furnishing of school lunches, paid for in part or in full out of public funds, to children in parochial schools; [5] supplying of surplus buildings and equipment, paid for out of public funds, to nonpublic institutions; [6] permitting teachers in religious garb to teach in the public schools and carry on what is in fact a parochial education at public expense; [7] placing the entire cost of some parochial schools upon public taxpayers, such as was attempted recently in North College Hill, Ohio.—NEA *Journal*

The world is a country which no one yet ever knew by description; one must travel through it oneself to be acquainted with it . . . . Courts and camps are the only places to learn the world in.

—LORD CHESTERFIELD

THE GRAPHING OF SINGLE-VALUED FUNCTIONS IN ONE UNKNOWN

JOHN N. MEIGHAN
Bowling Green State University, Bowling Green, Ohio

By a function of x is meant an expression that contains x and depends on its value for x. Thus, the expression x^2-x-20 is a function of x and is abbreviated by the symbol $f(x)$, $x^2-x-20 \equiv f(x)$.

If to every value of x there corresponds a value of y, y is said to be equal to a function of x: $y=f(x)$. The graph of $f(x)$ is the graph of the equation $y=f(x)$ and consists of all points with coordinates (x,y) that satisfy the equation $y=f(x)$.

The value of graphing in finding the real roots of $f(x)=0$ is realized once it is understood that these are the abscissae of the points where the graph of $f(x)$ touches the x-axis and that if $f(x_1)$ and $f(x_2)$ have different signs it does not necessarily mean there is a root of $f(x)=0$ between x_1 and x_2. Thus the function $1/x$ is negative for $x<0$ and positive for $x>0$ but $1/x=0$ has no root.

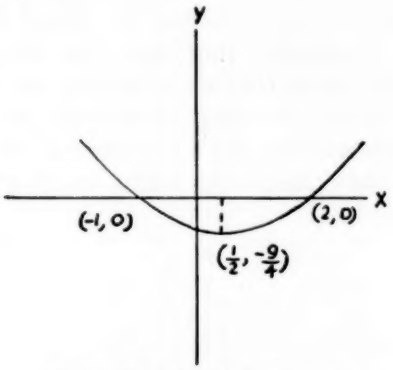


FIG. 1. Graph of $y=x^2-x-2$

To one graphing in beginning courses in algebra there is a question of how to connect points whose coordinates satisfy an equation such as $x^2-x-2=0$. This doubt can be removed by stating the assumptions that are made for the function to be graphed. Thus the function x^2-x-2 has a value for every number that is substituted for x, and it has only one value for every value that is substituted for x, so the graph must be a single continuous curve (see Fig. 1). The function x^2-x-2 is not linear so two consecutive points must be joined by a smooth curve,[1] and not by a straight line: the points $(0,-2)$ and $(1,-2)$ cannot be joined by the line $y=-2$ for the equations $y=x^2-x$

[1] Hart, Wilson and Tracy, *College Mathematics*.

-2 and $y=-2$ have only two solutions whose x-values are roots of $x^2-x=0$.

If there is doubt how the curve goes between two points with abscissae x_1 and x_2 additional points can be tested by using values of x between x_1 and x_2.

The roots of an integral rational equation

$$a_0x^{2n}+a_1x^{2n-1}+\cdots+a_{2n}=0, \tag{1}$$

where at least a_{2n} and one other a_i do not equal zero, are the roots of the equation

$$a_0x^n+a_1x^{n-1}+\cdots+\frac{a_{2n-1}}{x^{n-1}}+\frac{a_{2n}}{x^n}=0 \tag{2}$$

since

$$\frac{a_0x^{2n}+a_1x^{2n-1}+\cdots+a_{2n}}{x^n}\equiv a_0x^n+a_1x^{n-1}+\cdots+\frac{a_{2n}}{x^m} \tag{3}$$

except for $x=0$, and the roots of (1) (none of which is zero) make the left member of (3) zero. But some algebra texts require that the roots obtained by solving the first equation be tested in the second for extraneous roots. Graphing functions like $F(x)\equiv x^2-x-2$ and $f(x)\equiv x-1-2/x$ emphasize that the functions are different but that the roots of $F(x)=0$ are the roots of $f(x)=0$. $f(x)$ is undefined for $x=0$ so its curve has a break at $x=0$, otherwise the graph is a single continuous curve, that crosses the x-axis at $(-1,0)$ and $(2,0)$ (see Fig. 2).

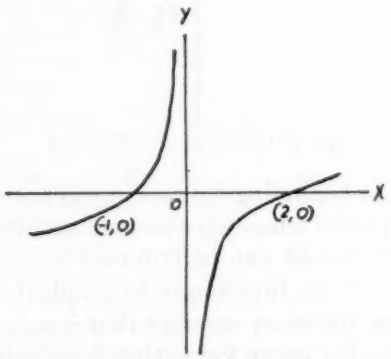


FIG. 2. Graph of $y=x-1-2/x$

In the case of a quadratic function ax^2+bx+c the bend point has an abscissa $-b/2a$. Thus the function x^2-x-2 has its minimum value for $x=\frac{1}{2}$ and the coordinates of the critical point of its graph are $(1/2, -9/4)$.

For polynomials of higher degree the abscissae of the critical points can be found by obtaining the real roots of $f'(x)=0$. But without the use of calculus some facts can be shown about graphing which can help to remove uncertainties about the behavior of the curve at a critical point and prepare the student better for calculus.

(I) If x_1 is a real multiple root of $f(x)=f(x_1)$ it is the abscissa of a critical point of the curve.

Proof: The line $y=f(x_1)$ and the curve $y=f(x)$ intersect (see Fig. 1) at points whose abscissae are roots of $f(x)-f(x_1)=0$. Since x_1 is a multiple root, by hypothesis, of $f(x)=f(x_1)$, and the ordinates of the points of intersection are equal when $x=x_1$, the line $y=f(x_1)$ is tangent ot the curve $y=f(x)$.

Illustration: The graph (see Fig. 3) of the function $f(x)\equiv 2x^3-3x^2-12x+10$ has a critical point whose abscissa is 2. For divide $f(x)$ by $x-2$:

2	−3	−12	10	|2
	4	2	−20	
2	1	−10	−10	

Divide $f(x)+10$ by $x-2$:

2	−3	−12	20	|2
	4	2	−20	
2	1	−10	0	

Let $Q(x)\equiv 2x^2+x-10$.

Divide $Q(x)$ by $x-2$:

2	1	−10	|2
	4	10	
2	5	0	

2 is a double root of $f(x)=f(2)$.

Similarly, -1 is the abscissa of a critical point, for $f(-1)=17$.

Divide $f(x)-17$ by $x+1$:

2	−3	−12	−7	|−1
	−2	5	7	
2	−5	−7	0	

Let $Q(x)\equiv 2x^2-5x-7$.

Divide $Q(x)$ by $x+1$:

2	−5	−7	−1
	−2	7	
2	−7	0	

and -1 is a double root of $f(x)=f(-1)$.

(II) If x_1 is a real root of even multiplicity, m, $(m>0)$ of $f(x)=f(x_1)$ the function of $f(x)$ has a relative maximum or a relative minimum at $[x, f(x_1)]$.

Proof: By (I) x_1 is the abscissa of a critical point. By hypothesis $f(x)=f(x_1)$ has x_1 as root of multiplicity, m, and therefore $(x-x_1)^m$ is a factor of $f(x)-f(x_1)$. Let $Q(x)$ be the quotient of $f(x)-f(x_1)$ divided by $(x-x_1)^m$; then $f(x)-f(x_1)\equiv(x-x_1)^m Q(x)$.

If $x-x_1<0$, $(x-x_1)^m>0$;

if $x-x_1>0$, $(x-x_1)^m>0$. $Q(x)$ cannot change sign at x_1, for x_1 is not a root of $Q(x)=0$. Therefore $f(x)-f(x_1)$ cannot change sign at $[x_1, f(x_1)]$ and $f(x)$ has a relative maximum or a relative minimum at $[x_1, f(x_1)]$.

Illustration: $F(x)\equiv 2x^3-3x^2-12x+10$ has a relative maximum at $(-1, 17)$ and a relative minimum at $(2, 10)$ (see Fig. 3).

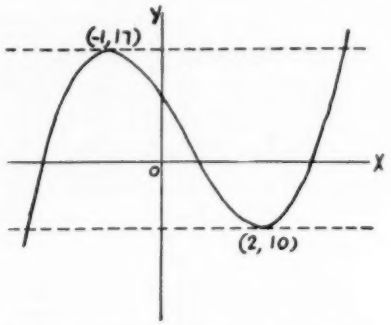


FIG. 3. Graph of $y=2x^3-3x^2-12x+10$

(III) If x_1 is a real root of odd multiplicity, m, $(m>1)$ of $f(x)=f(x_1)$ the function $f(x)$ has a point of inflexion at $[x_1, f(x_1)]$.

Proof: By (I) x_1 is the abscissa of a critical point. By hypothesis $f(x)=f(x_1)$ has x_1 as root of multiplicity, m, and therefore $(x-x_1)^m$ is a factor of $f(x)-f(x_1)$.

Let $Q(x)$ be the quotient of $f(x)-f(x_1)$ divided by $(x-x_1)^m$, then $f(x)-f(x_1)\equiv(x-x_1)^m Q(x)$.

If $x-x_1<0$, $(x-x_1)^m<0$; if $x-x_1>0$, $(x-x_1)^m>0$.

$Q(x)$ cannot change sign at x_1 since x_1 is not a root of $Q(x)=0$. Therefore the curve $y=f(x)$ crosses the line $y=f(x_1)$ at $[x_1, f(x_1)]$.

Illustration: $f(x)\equiv x^3-3x^2+3x-1$ has a point of inflexion at (1,0) (see Fig. 4).

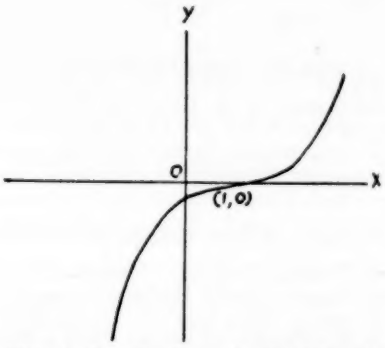


FIG. 4. Graph of $y=x^3-3x^2+3x-1$

(IV) The graph of a polynomial, $f(x)$, of degree n, with real coefficients, crosses the x axis an even number of times if n is even and an odd number of times if n is odd.

Proof: If there are imaginary roots of $f(x)=0$ their number must be even, since if $a+bi$ is a root of $f(x)=0$ its conjugate is also a root.[2] Let their number be $2c$. Then there are $n-2c$ real roots.

Let the roots of even multiplicity be $2d$ in number.

The remaining $n-2c-2d$ roots are of odd multiplicity, m, $(m \geqq 1)$. Let $q_1, q_2 \ldots, q_k$ be the roots. Then the graph of $f(x)$ crosses the x-axis once at each q_i and hence k times by the above proofs. Since the number of times q_i occurs as a root is an odd number, m_i, and $m_1+m_2+\ldots+m_k=n-2c-2d$, k must be an even integer if n is even, and k must be an odd integer if n is odd.

Illustration: $f(x) \equiv 2x^3-3x^2-12x+10$ crosses the x-axis three times (see Fig. 3).

[2] Dickson, *Theory of Equations*.

PROF. J. D. ELDER TO BE SCIENCE EDITOR AT HARVARD

Prof. J. D. Elder, of the Wabash College physics department, has accepted the position of science editor of the Harvard University Press, Cambridge, Mass.

He will leave Wabash at the close of the 1947–48 school year.

Prof. Elder came to Wabash in March 1944 during the Navy V-12 program. Previously he had taught at the University of Vermont, Haverford College, and Lynchburg College. During the early days of the war he was engaged in the editing of technical reports for the National Defense Research Committee in Washington D. C. At Wabash he and Prof. Duane Roller, head of the physics department, revised and edited, for the Navy, a translation of Cranz's "Lehrbuch der Ballistik," the world's principal reference work on ballistics.

Since 1944 Prof. Elder has been assistant editor of the *American Journal of Physics* and physics research editor of SCHOOL SCIENCE AND MATHEMATICS.

ON TO INDIANAPOLIS

The 1948 convention will meet at the Claypool Hotel in Indianapolis, Indiana on Friday and Saturday of November 26 and 27. The following local committees are even now planning in true Hoosier fashion for your comfort, for your edification and for your enjoyment. Watch for additional announcements in the JOURNAL.

General Chairman: Mrs. Marie Wilcox, George Washington.

Local Membership: Carl Hanske, Chairman, Manual; Martha Hunt, Shortridge; Albert Mahin, Broad Ripple; Arthur Hoffman, Arsenal Technical; Elizabeth Hester, George Washington; Glen Ludlow, Howe; Belle Ramey, School 76; Nina Martin, Ben Davis; Gladys McColgin, Tudor Hall; Br. Albert Pinter, Cathedral.

Publicity: Mona Jane Wilson, Chairman, Shortridge; Eva Thornton, Manual; Panoria Apostol, School 52.

Trip: Howard Wright, Chairman, Eli Lilly Laboratories; Walter Geisler, Shortridge; H. H. Siemers, Shortridge; Mildred Campbell, Shortridge.

Registration: Albert Mahin, Chairman, Broad Ripple; Grace Barker, George Washington; Edith Silver, Arsenal Technical.

Exhibits: Charles Brosey, Chairman, Arsenal Technical; Newell Hall, Arsenal Technical; Howard Cook, Arsenal Technical.

Banquet: Mrs. Henrietta Parker, Chairman, Shortridge; Beth Wilson, Shortridge; Eleanor Guyer, Southport; Mildred Corrie, Arsenal Technical; Byrl McClure, School 72; Lillian Niemann, George Washington; Arthur Sims, George Washington; Robert Green, Broad Ripple.

Facilities for Meetings: Virgil Heniser, Chairman, Howe; Richard Hammond, Howe; Ada Coleman, Manual; Rowland Jones, George Washington; Kenneth Barr, Arsenal Technical.

Hospitality: Miriam King, Chairman, Broad Ripple; Ruth Reed, Howe; Mabel Washburn, Shortridge; Mrs. Beverly Thompson, Speedway; Mrs. Mildred Loew, Howe.

Statistics: Enoch Burton, Shortridge.

Social Hour: Houston Meyer, Chairman, Arsenal Technical; Mildred Ross, George Washington; Robert Belding, Arsenal Technical; Betty Lowery, Arsenal Technical; Estel Van Dorn, George Washington.

Noon Program: Vivian Ely, Chairman, George Washington; Paul Wetzel, Arsenal Technical; Ross Stacy, George Washington; Lola Eller, School 67; Ann Suter, Purdue Extension Center.

Plan now to attend the 1948 convention at Indianapolis.

J. E. POTZGER, President
Butler University

FRENCH ATOMIC SCIENTIST NAMED TO UNESCO POSITION

Prof. Pierre Auger, French atomic energy expert after whom cosmic ray bursts are called Auger showers, is the new head of UNESCO's natural sciences section, succeeding Dr. Joseph Needham, British biologist who is returning to his professorship at Cambridge University.

THE PRESENT FORESTRY SITUATION IN THE LAKE STATES*

R. N. CUNNINGHAM

Forest Economist, Lake States Forest Experiment Station, University Farm, St. Paul, Minnesota

The northern Lake States region frequently has been characterized as an area of devastated timberlands and infertile soils where people must suffer indefinitely from lack of economic opportunity. I want to hasten to disclaim any such pessimistic view of the regional situation. Of course, one must recognize that some constructive things will have to be done with timberlands and other natural resources if this area is to reach its full possible degree of development.

Before elaborating on present conditions, let us consider a little background.

ORIGINAL FOREST

In the original forest, the general nature of the tree associations was determined largely by climatic factors. In the cool northern division was a forest of conifers or softwoods, in the south a forest of hardwoods. To the west, with decreasing rainfall, the forests gave way to brush fields and open prairies.

Within the broader associations, the timber types were influenced strongly by topography and soil, the soils being largely of glacial origin. The sandier moraines and outwash plains were taken over largely by the white, red, and jack pines. The heavier northern soils were occupied by white spruce, balsam fir, and hemlock. Swamps, such as the saturated peat beds in northern Minnesota once occupied by glacial Lake Agassiz, are now occupied by black spruce, tamarack, and cedar.

Hardwood forests were of three main types—the northern hardwoods, made up of sugar maple, yellow birch, basswood, and beech; the mixed oak types; and the bottomland hardwoods.

The original forests occupied about 100 million acres, or 82 percent of all lands in the three states of Minnesota, Wisconsin, and Michigan. About half of this was the softwood type and half hardwood.

During the period of settlement and resource exploitation, about 44 percent of the original forest was cleared and devoted to other uses, and the acreage remaining in forest was changed very greatly in regard to volume and composition of timber stands.

The story of pine lumbering starting on a large scale in the Lake

* Read at the Conservation Group Program of the Central Association of Science and Mathematics Teachers, November 29, 1947.

States after the Civil War and extending to the first years of the present century is too well known to require review. Virtually the entire virgin forest of white and red pine was liquidated over a period of 40 to 50 years. Removal of the virgin hardwood and hemlock forests came later, but is now nearly complete.

Nor is there need to review the tragic record of forest fires, including the holocausts of 1871, 1881, 1894, 1910, and 1918. Over a period of 76 years these caused 2,845 deaths and burned many millions of acres of forests and marsh. Pine seedlings that came in after lumbering were usually destroyed by slashing fires.

Then there was the vast waste of timber which accompanied the clearing of farms and pastures, including in many cases the most reckless use of fire.

These are events of the past and cannot be changed. Thinking of them serves only to explain why the forests of the region are in such rundown condition and why current progress is rather slow in organizing public and private forests on a profit-making basis.

Before the War

A forest inventory completed in 1936 showed that the original 100 million acres of forest had been reduced to about 56 million acres, and the original 800 billion board feet of timber had been reduced to about 56 billion board feet. Virgin saw timber stands had been reduced to about $3\frac{1}{2}$ million acres, supporting 32 billion board feet of timber.

At that time the effects of forest destruction were being felt in several ways. The first was a drastic decline in some of the forest industries, notably the large sawmills. Census figures for lumber and timber products showed more than *116* thousand men employed in 1889, not quite *52* thousand in 1919, and only *21* thousand in 1937. In 1929 there were still *87* large sawmills in the region, but in 1936 only *41* remained and most of these were expected to close within a period of 10 to 15 years.

A wave of tax delinquency was enveloping the northern counties. It reached its peak during the depression when owners of, roughly, 20 million acres of forest land failed to pay taxes. About $12\frac{1}{2}$ million acres of abandoned land reverted to public ownership. During 1933, 7 counties in northern Minnesota collected less than 50 percent of the current levy, and one county had a delinquent return of 78 percent. Some individual towns and school districts had a delinquency of over 90 percent. Efforts to restore these lands to the tax rolls by bargain tax settlements, installment payments, and repurchase privileges proved fruitless.

Forest destruction likewise contributed to a serious relief problem

in northern Lake States communities. The wealth and income of the average family in the forest region is considerably lower than in other parts of the region. From 1924 to 1935, for example, the income from the sale of crops, livestock, and livestock products averaged only $335 per farm in northern Minnesota, while for the state as a whole the average as $1,371 per farm, or four times as much. Public services and institutions in the cutover areas were below the standards maintained in more populous districts. There was less electricity, fewer telephones, very few doctors, practically no well-equipped hospitals in many of the rural areas. In all three states, the percentage of total populations on relief was higher in the northern portions than in the rest of the state. In Michigan, in December, 1934, 34 percent of the people in the Upper Peninsula were on relief as compared to 17.8 percent for the entire state. In June, 1938, over 79 thousand residents in the 14 cutover counties of Minnesota were receiving public assistance or work relief of some sort. This represents almost 23 percent of the 1930 population, as compared to about 12 percent for the state as a whole. Similarly, in 1938, Wisconsin had 11 counties in which more than 30 percent of the population were receiving aid. In one county well over 70 percent of the population received some sort of public aid during 1937.

Forest destruction contributed also to a rather serious soil erosion problem in southwestern Wisconsin and adjacent counties in Minnesota. In this unglaciated district of comparatively rough topography and wind-blown soil, the land suffers seriously from gullying and sheet erosion. This is a dairy section and farmers are inclined to clear the hillsides for pasture and to run stock in the woods. When the steeper slopes are cleared, erosion starts and may extend to the more level lands below.

Effect of War

For a period during the war, lumber was more critical than steel. Vast quantities were needed for camps, boats, gliders, and for crating overseas shipments. Paper was needed to package food supplies and to protect war equipment for shipping. Veneer was needed for planes and boxes. From a prewar average of 25 billion board feet per year in 1936 to 1940, United States lumber production was lifted above 35 billion board feet in each of the war years. Pulpwood deliveries, about 10 million cords per year from 1937 to 1939, increased to 15 million cords in 1943. Veneer logs and many other products followed a similar course. Paralleling the national trend, Lake States lumber increased from 804 million board feet in 1938 to 1,228 million in 1944. Pulpwood consumption increased from 1,496,000 cords in 1938 to 2,474,000 cords in 1944.

The impact of this heavy demand upon the standing timber resources of the region was drastic.

Between 1936 and 1945, about one third of the remaining old growth pine and northern hardwood timber was logged mostly by clear-cutting. Theoretically, these old-growth stands will support another 20 years of such cutting. Actually, some are too inaccessible or too poor to justify logging. The recent heavy cutting, concentrated as it had to be because of shortage of labor and transportation equipment, made heavy inroads in the accessible and easily logged, while leaving the more remote timber to deteriorate, fall down and rot on the ground. Thus the majority of lumber companies dependent upon old-growth stands will be cut-out in much less than 20 years. Present indications are that only 8 of the remaining 24 large sawmills have access to sufficient stumpage to continue large-scale operations for more than 15 years.

More serious than the reduction in virgin stands has been the heavy cutting in thrifty young stands just beginning to reach merchantable size. About one-sixth of all of the spruce large enough to make pulpwood was cut during the period. If one considers only the acreages that are fully accessible and loggable, the cut percentage is nearer 25. Similarly, more than 30 percent of the jack pine sufficiently large for pulpwood was cut. In some localities, more than 50 percent was taken. Most of this logging also was clear-cutting.

So great was the demand for pulpwood that companies lowered their quality and size specifications considerably. Instead of requiring that pulp sticks be at least 4 or 5 inches in diameter at the small end, some accepted 3-inch and even $2\frac{1}{2}$-inch sticks. While this tended to encourage closer utilization of tree tops, it also encouraged cutting of smaller trees and in some cases led to cutting of whole stands scarcely out of the sapling stage.

A number of pulp and paper companies, like the large lumber companies, are beginning to see the bottom of the timber supply barrel.

In short, the region already has reached the end for practical purpose of its old-growth white and red pine. It is fast reaching the end of its old-growth sugar maple, yellow birch, and hemlock. It is running short of spruce and pine pulpwood.

Overcutting must be tolerated in time of war, but it must be offset by remedial measures after the war if the country if not to be exposed to the danger of being wholly unprepared for possible later emergencies. Let us consider some of the things that can be done.

Trend Toward Better Utilization

In spite of reduced supplies of saw timber and pulpwood of the

kinds which have supported the large sawmills and pulp mills in the past, the region still has considerable usable raw material and a large timber-growing potential.

One item is aspen. This type occupies nearly 20 million acres or 39 percent of the forest area. Already there is enough timber of merchantable size to supply nearly twice the quantity of saw timber and three times the quantity of cordwood now cut from this species. The cut of aspen lumber and pulpwood more than doubled between 1940 and 1946. The species now yields about 12 percent of all sawlogs and 18 percent of all pulpwood cut in the region. There is much interest and some possibility of extending the life of existing industries and introducing new ones with aspen.

Development of hardwood pulping processes opens up new opportunities for Lake States woods. While supplies of high-grade saw timber are shrinking, the available supply of pulp-size material is very large.

The war demands likewise stimulated technical advances in both physical and chemical utilization of wood, such as improved veneers and glued-up timbers, chipped and defiberized products. These should facilitate greater use of some Lake States hardwoods now going to waste.

With continued research and further improvement of manufacturing processes, much can be done to expand the uses of existing material in this region.

Natural Reforestation

Excluding the small remaining acreage of old-growth saw timber and some 5 million acres of noncommercial land, the Lake States have about 34 million acres of second-growth forest with trees ranging in size from mere seedlings to those large enough to make small sawlogs. This acreage includes about 1 million acres of planted area, a little more than 19 million acres of natural reproduction, and a bit less than 14 million acres of pole-size and larger.

More than 40 percent of the second-growth forest is aspen, and some of the other stands are made up in part of inferior species. Characteristically, they are understocked. Taken together, the stands have only about half the number of trees and timber volume (growing stock) needed to make the land fully productive.

The past 10 to 15 years, while the region has had an exceptionally good record of fire prevention, have enabled many of the young timber stands to "thicken up." Even where no new sprouts or seedlings have appeared, the stands have become more dense through enlargement of the existing trees,

Probably a more significant development has been a gradual reseeding of deforested lands and a slow natural conversion of aspen to more valuable types. We have no exact measure of the rate of afforestation, but estimate that the acreage of deforested and poorly stocked land has decreased by about 7 million acres during the past 10 years. A large part of the new seeding has been aspen, but at the same time enough aspen has evolved into other types that the area of aspen type is no larger than it was 10 years ago. On the other hand, the acreage restocking with softwood has increased by more than 2 million acres.

This natural improvement occurring even during a period of heavy cutting when the country was too preoccupied with winning a war to give much attention to forestry needs emphasizes the great possibilities that lie in simply helping nature rebuild a productive forest. The axiom that nature abhors a vacuum has a corollary—nature abhors barren land. Foresters should take advantage of these natural trends and stimulate conversion to better types by intensified protection, selective cutting, and judicious interplanting.

Artificial Reforestation

Greater use of aspen and other hardwoods may tide over the Lake States forest industries for a period, but it will never make this region a timber-exporting area nor even a self-supporting area. The greater need both in lumber and pulp is for softwood species.

To enable the forests to produce the quantity of softwood timber desired without an unduly long delay, the forest landowners will need to plant large acreages to pine and spruce.

The region now has about 14 million acres of deforested or poorly stocked land. Foresters urge a long-range steady program of planting.

Public Forestry

I can touch only lightly some of the organizational and economic problems that need to be solved in connection with carrying out a good forestry program in the Lake States. Some of these are of real importance.

About 42 percent of the commercial forest land is now in some form of public ownership, but several million acres of that portion which has rather recently reverted for nonpayment of taxes is held in a purely custodial status without constructive efforts being made to restore it to productivity. Some of the worst examples of premature cutting over have been found on lands of this status. The public unquestionably has an opportunity and a responsibility to do something better with this land.

The established state and federal forests still require improvement. They need land exchanges to avoid conflicting jurisdiction. More than 3 million acres need planting. Large additional areas of struggling pine, spruce, and fir saplings need to be released by light cutting Access roads should be built. Scattered decrepit trees should be removed.

The three states have a creditable record in fire protection during the past 10 years, but it is probable that the CCC program during the first part of the period and favorable weather during the last part contributed toward the good results. Experts feel that there should be further strengthening of preventive and control machinery in a number of places. Machinery for protecting private lands against insects, disease, and trespass is almost wholly lacking.

The states have been giving more and more aid to counties both in the nature of general aids for schools, roads, relief, and so forth, and specific aids for forest purposes, the former to help relieve the excessively heavy burden of property taxes on private lands, and the latter to stimulate better management of county forest lands. These aids must be continued and increased.

Industrial Forestry

A number of wood-using industries, particularly pulp and paper companies, have recognized the need for restoring local timber supplies, and are engaged in buying land, planting trees, and carrying on educational campaigns in the interests of better fire protection and better forest management.

But private owners still face some rather serious handicaps in practicing sustained-yield forestry.

The tax systems, both the local property taxes and the federal income and inheritance taxes, operate to discourage sustained-yield forestry. States in the region have passed special forest tax laws which have helped in many cases but they are not widely operative.

Existing credit facilities are not well adapted to forestry operations.

In some cases an antagonistic public attitude toward corporations in general and timber companies in particular operates to forestall such things as cooperative sustained-yield units. Some people have not learned to discriminate between progressive timber companies and those still trying to "cut and get out."

Forestry by Small Private Owners

Practically half of the forest land in the Lake States is owned by some 600,000 or more small timberland owners. This half includes some of the poorest forests and some of the most poorly managed land

in the region. It presents probably the most critical immediate problem for foresters.

A number of things are being tried—some quite successfully—to improve forest management on these small holdings. What is needed mainly is an enlargement and intensification of these efforts. Let me mention a few of the more productive ones.

1. Extension Foresters. Each state has at least two extension specialists working through the Agricultural Extension Service (county agents) to demonstrate improved forest practices. A few counties have assistant county agents who are primarily foresters. Many other counties would be greatly helped by men of this kind. The Extension Service is doing some excellent work also with 4-H Club Conservation Camps.

2. Farm foresters in the employ of the State Conservation Departments give advisory service to farmers on timber-cutting and marketing of products. The few now employed have more work than they can do.

3. Industry-supported agencies, such as "Trees for Tomorrow" and "Keep Minnesota Green," distribute fire-prevention and forestry literature, hold conservation meetings, distribute trees for planting, and stimulate conservation activities in the schools.

4. Forestry education in the grade schools and high schools is being stimulated by conservation camps run by the Michigan Conservation Department at Higgins Lake and by the University of Minnesota at Itasca Park. The St. Louis County (Minnesota) school system employs a full-time forester to work with the teachers of rural high schools.

5. Conservation districts which are being organized in many of the southern counties, primarily for soil conservation in which forest management often plays a prominent part.

6. AAA Conservation program. Farmers are being reimbursed in part for expenditures in planting windbreaks and timber groves and in some states for improving the natural forest growth on their land.

7. Forest product cooperatives. Certain groups of farmers have been able to increase their income from forest products by pooling their output—sorting their veneer logs for one market, their sawlogs for another, their pulpwood for a third. They have not gone as far as in some other regions in actually processing forest materials or in banding together for the purpose of managing their woodlands.

8. Research agencies have been trying to contribute to the better management of private forests through forest surveys, timber utilization studies, and research in methods of planting, thinning, and harvesting of forest crops. A little work has been started in tree breeding. All of this has been on a comparatively small scale.

In this brief paper I have tried to describe in a general way the present condition of the Lake States forests, to explain the principal reasons for this condition, and to touch on some of the remedial measures that are being tried.

After seeing this picture, I think you will agree with me that the greatest single need at this time is an enlightened public understanding of the forestry problems faced by both public and private landowners.

To me it is a very encouraging thing that science and mathematics teachers have such a genuine and intelligent interest in the forest situation, because they are in a position to interest the coming generation in the problems they will have to face some day. I am not thinking of special lectures or special assignments so much as the opportunities you have to bring in interesting conservation material as examples for problems in physics, mathematics, chemistry, and biology.

SUMMER LABORATORY WORKSHOP IN SCIENCE FOR ELEMENTARY AND HIGH SCHOOL TEACHERS

During the summer of 1948 Washington University will offer a laboratory workshop for science teachers. The course is sponsored by the Department of Education with the cooperation of the departments of zoology, botany, chemistry, geology and physics. The course offers an opportunity for teachers and potential teachers to develop laboratory and demonstration techniques, equipment and exercises in connection with classroom work on the elementary and high school level.

The work will center about problems presented by teachers in connection with their classroom work in science. It is expected that the majority of the students will have some specific problem in mind but provisions will be made for those who would like to participate in the solution of problems presented by others.

A limited number of lectures on (1) recent developments in science; (2) the place of science in the total culture; and (3) the scientific method will be given. The nature of these lectures will depend on the interest and background of the applicants.

Prospective applicants are invited to submit inquiries to either

Ernestine M. J. Long
Normandy High School
St. Louis 14, Missouri

or to

Professor Alexander Calandra
Division Physical Sciences
Washington University
St. Louis 5, Missouri

and to indicate their general area of interest and specific problems, if any. Registration in the course will be limited to the facilities available. The course will run from June 14 to July 23 and will carry 3 or 6 hours credit and will meet 6 or 12 hours a week. Tuition is $37.50 for 3 credit hours. Graduate credit will be given in the Department of Education or in any one of the departments mentioned above.

Today is a new day. Begin it well and serenely. It is too dear with hopes, possibilities, aspirations and invitations to waste a moment on yesterday.

—RALPH WALDO EMERSON

A REPLY TO E. LAURENCE PALMER: YEARBOOKS AND SCIENCE EDUCATION[1]

GEORGE GREISEN MALLINSON AND KENNETH E. ANDERSON
Iowa State Teachers College, Cedar Falls, Iowa

Before presenting their reply to Dr. Palmer, the two writers wish to make absolutely clear several points. First, they have no vested interest with respect to the 31st and 46th Yearbooks of the NSSE,[2] since neither had any part in preparing them for publication. The opinions here expressed are, therefore, solely their own. Secondly, they do not consider themselves among the "plenty of yes men in professional science education who will praise anything they see in print,"[3] to whom Dr. Palmer so caustically refers, and, finally, they have carefully read Dr. Palmer's chapter, "General Comments on the Yearbook by a Fellow-Worker in Science" in the 31st Yearbook, attended the meeting where Dr. Palmer delivered the address to which this reply is directed, and have carefully read the published report of his address.

As educators interested in the development of science education, they not only believe that the airing of criticisms and comments concerning published works is an inalienable right in a democratic society, but further, they believe that the voluntary withholding of such comment is a profound disservice to education. The writers respect Dr. Palmer's right to speak freely and expect that he will grant them that right in return. It is in this spirit that this rebuttal is presented.

As science educators, "even at the risk of being accused of 'using moral and religious interpretations of biological phenomena' by even mentioning the Deity,"[4] the writers wish to refer to the Biblical passage, "He that is without sin among you, let him first cast a stone . . . ."

In the 31st Yearbook in Dr. Palmer's commentary the following statement appears, "Nature Study cannot be 'killed' by the burning of so unrepresentative a straw man as that set up . . . ." In the address, and in its published report, now being criticized Dr. Palmer paraphrases this comment by stating "In the thirty-first yearbook, the committee erected a straw man that they called Nature Study.

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[1] Palmer, E. Laurence, "Yearbooks and Science Education," SCHOOL SCIENCE AND MATHEMATICS. XLVIII (March 1948), 183–198.

[2] *A Program For Teaching Science.* Thirty-first Yearbook of the National Society for the Study of Education, Part I. Chicago: Distributed by the University of Chicago Press, 1932.

Science Education in American Schools. Forty-sixth Yearbook of the National Society for the Study of Education, Part I, Chicago: Distributed by the University of Chicago Press, 1947.

[3] *Op. cit.* p. 184.

[4] *Op. cit.* p. 197.

They clothed it in the worst sort of ideas and then destroyed it and began to crow." The writers are vehement in stating that Dr. Palmer, in his commentary on the yearbooks, has done almost exactly that!

Dr. Palmer, however, erected the Dvorak test, superimposed the title "31st and 46th Yearbooks" on the title of the test, destroyed it, but instead of crowing, played records of bird calls, and frog croaks.

These writers believe that the commentaries, with especial reference to that published in the March 1948 issue of SCHOOL SCIENCE AND MATHEMATICS have, with or without intent, avoided coming to grips with the major issues and areas developed in these yearbooks.

It is recognized that "valid conclusions cannot possibly be reached through the use of invalid data collected by the use of invalid instruments of measurement,"[5] but likewise one poor apple is not sufficient reason for condemning the bushel.

Assuming that Dr. Palmer's evaluation of the Dvorak tests were correct, the persistence with which he has condemned the 31st and 46th Yearbooks because of the references to the test contained in them belies the presence of scientific attitudes. The validity of these yearbooks does not depend upon the validity of this test. Dr. Palmer has expanded the references to it all out of their true proportion and place. In the yearbooks the Dvorak test represents an infinitesimal apple indeed.

Further, the fact that the Dvorak test was used or referred to in Curtis's thesis, in Curtis's "Digest of Investigations in the Teaching of Science," in Cunningham's evaluation of science tests, in Noll's evaluation of science tests in "Teaching of Science in the Elementary and Secondary Schools," and finally in Dr. Curtis's section in "The 1940 Mental Measurements Yearbook" is entirely extraneous with respect to the validity of the Yearbooks. Is this not the recurrent "straw man"?

The writers would further question Dr. Palmer's references to recommendations he received from members of the yearbook committees for applicants for a position on his staff. Whether or not he believed these recommendations to be worthwhile, can the value of the recommendations be used as a criterion for the worth of these yearbooks?

The writers are in agreement with Dr. Palmer that certain fields with respect to the teaching of science do not appear in these yearbooks. Perhaps they should have been. However, they do realize that the published work was a yearbook, not an encyclopedia. The criticisms then should be directed not so much toward the inclusion or

[5] *Op. cit.* p. 185.

exclusion of certain materials, but rather toward the criteria used for selection of that which was included.

The writers have always respected Dr. Palmer's work in the area of conservation, nature study and especially in the publication of the excellent "Rural School Leaflets." However, they believe that in his commentaries Dr. Palmer has been expressing rancor against a test for which he holds no brief, and against men who propound a science philosophy with which he is in hearty disagreement.

There is no desire on the part of the writers to carry on a running feud, hence, this constitutes their last statement on this subject. It is hoped, however, that further comments from Dr. Palmer will deal with the pertinent issues, and will avoid diatribes, which only serve to impede the progress of science education.

THE PACIFIC INDUSTRIAL CONFERENCES AND CHEMICAL EXPOSITION

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Plastic bubbles that became balloons, small magnets and magnetic plates of unexpected strength, flasks wrapped in individual Arctic-like jackets, distillation columns actively separating a deep violet liquid into liquids of various lavender shades, clicking Geiger counters flashing lights like a "scientific" movie production, arrays of industrial equipment, some of which were Rube Goldberg-like in character, hundreds of new chemicals, a very intelligent robot, and hours of free movies, were impressions produced by the physical make up of the Chemical Exposition held in the San Francisco Civic Auditorium between October 21st and 25th, 1947. Accompanying the exposition were a series of conferences of western industrial groups, the whole being the first of what is hoped to be a biannual activity. The program was started and sponsored by the California Section of the American Chemical Society.

The plans for the Exposition show 109 booths occupied by 128 different Exhibitors, and other booths for special exhibitors including: The United States Department of Agriculture, the U. S. Geological Survey, the National Bureau of Standards, the American Society for Testing Materials, and the Special Libraries Association. Other special exhibits were: a display of hundreds of new chemicals, some exhibited for the first time, others first exhibited in 1946 at eastern expositions, each accompanied by a statement prepared by Robert L. Taylor, Editor of Chemical Industries and an exhibit of posters on

Atomic Chemistry prepared by Walter Murphy, editor of Industrial and Engineering Chemistry.

The movie program began at 1 o'clock each afternoon and ran continuously until around 10 in the evening. It was necessary to spend most of two days plus several hours on a third day in order to see all of the 30 movies presented. A committee of the California Section of the A.C.S., headed by Dr. Richard Wistar, selected these films for their educational and scientific value. As would be expected in so extensive a selection of educational films, most of which were of the "industrial" type, some were old and others were relatively new. Many were in color. Among those viewed and considered excellent by the author were: "Alchemists in Hollywood," "Glass for Science," "Hawaiian Harvest," "Seashore Oddities," and "This is Aluminum." The only advertising in these is the sight of labels in packaging processes and views of a factory or two. The first film is an excellent one on photography for a science class studying the photographic processes or for a photography or camera club.

Funnels and filter paper are not the only way of filtering liquids. This was demonstrated by the many different types of industrial filters on display in various booths. Filter presses, filter discs, filter plates and filtering columns or chambers were all represented. The principle of most of these is a basic supporting screen. Liquids are forced from the outside to the inside of these devices, or from the top to the bottom. The precipitate or solid material remains on the outside where it may be washed, partly dried by suction, and then flushed or knocked off for further treatment. Some screens are fine enough to remove coarse solids without other means. Sometimes cotton or asbestos cloth is used as the filtering medium supported by the screen. Other filters use fuller's earth or fibrous asbestos to form a filtering coating on the supporting screens. This last idea is similar to the preparation and use of the Gooch crucibles used in laboratory work for certain filtrations.

Cooling devices, gas cleaners, gas flow control apparatus, and mixers or blenders for both laboratory and industrial use were on display. These varied from the small glass condensers and milk shake mixers to large coolers similar to those at an ice or ice cream manufacturing plant and to mixers that will blend or knead large amounts of materials, both liquid or plastic solid, until they are of uniform consistency.

Stainless steel was much in evidence throughout the exposition hall. Corrosion resistant metals of other types were there in the forms of pipes, connection devices, valves, and other operational equipment. Plastics including neoprene and other rubber-like synthetics

were also in evidence in operational equipment such as pumps and filters. There were exhibits showing the many ways in which aluminum and magnesium alloys can be used, and those illustrating methods of solving the packaging and labeling problems of industry. In many ways the exhibits seemed at first glance to be mechanical displays rather than chemical showings. A little thought soon brought the realization that all these mechanical devices could not exist if some place along the line of their manufacture there had not been much time and expense devoted to research and the development of the materials used in the construction of the apparatus. This was the chemistry we went to the exposition to see, chemistry applied to industry. At the same time these mechanical exhibits illustrate the contribution of the mechanical industries to the chemist. Were not these exhibits developed for the chemical trade to observe, to critically analyze as to suitability, and to later purchase for use? In two more years, if plans for the exposition are successful, we will be back again to see the new mechanical adaptations of new materials developed by the chemists. Such developments may be possible because of some of the adaptations that were presented for the first time at this exposition. The exchange of new developments between the chemical and the mechanical or engineering forces is essential to continual progress.

The above are extracts from a very unusual and interesting report by the author to the editor of your Journal. We wish we could publish the complete report.—G. W. W.

SUMMER COURSE IN PHOTOGRAPHY FOR TEACHERS AT ROCHESTER INSTITUTE OF TECHNOLOGY

A six weeks course in Photography for teachers in secondary schools will be offered by the Department of Photographic Technology of the Rochester Institute of Technology beginning July 12th. The course will require 30 hours weekly and includes (1) Theory of Photographic Processes, (2) Teaching Methods in Photography, and (3) Lectures on practical photography with work in the studio and laboratory. The projects have been arranged so as to provide teachers with material which may be used for teaching purposes in their own classes or club activities. The course has been approved by the New York State Department of Education for in-service credit. Applications close May 15th. For particulars write, Department of Photographic Technology, Rochester Institute of Technology, Rochester 8, New York.

The mysterious electron, that fundamental building block of matter which dances in our radio tubes to the tunes of our favorite orchestra, dances likewise in the atoms of the distant stars, in the vast interstellar spaces, and even in man himself.

—HARLAN TRUE STETSON

THE PLACE OF ELEMENTARY SCIENCE IN THE CURRICULUM

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The topic suggested to me for this meeting is a very broad one. It gives me leeway to say a great variety of things, or to present my pet ideas about elementary science. Much has been written and said on the topic in the past few years. Some of it based on studies, some of it based on pet ideas, some of it generally accepted, some of it still controversial. Today I shall not try to analyze this material in terms of its validity but shall try to present some of it in a form that will perhaps have a direct meaning and application for the teachers who make no claims to being science specialists. I assume that you are all interested in science teaching, otherwise you would not be at this meeting. Also I assume that you know more science than the average elementary teacher, otherwise you would not be interested. However, I think that it may be profitable to review some of the reasons for including science in the elementary curriculum. Then, from the value of the reasons, we may be able to reach a fair conclusion as to the place that science should have in the elementary school.

To insure that we are all thinking about the same thing, first we need a definition of science and of elementary science. As I remember the first definition of science that I learned—or perhaps the first that stuck in my mind fully—science was defined as "organized knowledge." I have heard other definitions suggested to the beginning student, but on analysis they merely say the same thing in a less cryptic form. That definition seems to have been satisfactory for the time when the scientist could be an inhabitant of an ivory tower and take little if any part in the affairs of society. If is of interest to find in the recent writings on science education at almost any level that the definition is being enlarged to include the influence of society on science and the influence of science on society, including in the definition the impact of the science discoveries on society and on the thinking of men. Dr. Conant in his book *On Understanding Science* in defining what he means by science says,

" . . . we may say that science emerges from the other progressive activities of man to the extent that new concepts arise from experiments and observations, and the new concepts in turn lead to further experiments and observations . . . . The texture of modern science is the result of the interweaving of the fruitful concepts. The test of a new idea is therefore not only its success in correlating the then-known facts but much more its success or failure in stimulating fur-

ther experimentation or observation which in turn is fruitful."

By this definition science is more than a collection of organized facts. It is a constantly changing, progressing activity that has an influence beyond the facts discovered. The student who can attain this concept of science will be a longer way toward an understanding and appreciation than the one who has only the former definition in which science is made to seem something rather fixed and definite. As I use the term science, I like to include this progressive, building idea. Also, as ordinarily used science means the fields of knowledge that we include in the usual courses of physics, chemistry, biology, and earth science. For this discussion we will limit the term science to these areas, although I know that there are those who would include some of the social studies and psychology. Actually these latter are the study of man and his relation to himself and to the others about him. As such, they have the same base as do the other sciences, a desire to find out about the world and to help the individual to become adjusted to life in the world as it is.

For this discussion, then, we will define science as that branch of knowledge or human endeavor that is concerned with the study of the physical environment, the determination of the facts and concepts that enable man to understand and control that environment. This determination at any period leads to other questions and determinations as well as having an impact on the society of the period. Since there is an impact on society, science specialists have a responsibility to help the layman in science to an understanding of how the discoveries do influence society. It is in the latter that the teacher becomes an important part of the science program of any country. It is the teachers of any country that give to the general population their basic understandings, their knowledges and appreciations of what has been done in the previous periods of investigation and study. It is the teachers who are the bridge between the research scientist and the layman. It is they who take the discoveries of the scientist and put them in terms understandable to the layman.

Elementary science is the facts and concepts of science that are understandable by the children of the elementary school. This seems almost axiomatic. The controversies arise when we try to determine just what those facts and concepts are. I shall not attempt to solve that problem. I think to a surprising extent they are the problem of the individual school and teacher, depending upon the situation of the school and the background of the students. I do wish to suggest one general rule that seems to me to be applicable to all schools and age levels. I suggest it to my students when they come asking "what shall I teach in science?" This rule is: If a concept cannot be presented in terms the child can understand and yet give no

misleading impressions or interpretations that will have to be corrected later, it should not be taught until the child's experience makes such an explanation possible. The grade placement of many concepts will vary as the experience of the children will vary. Children along the coast will learn about tides much earlier than the children in the middle of Iowa, for to them the tides have a much greater meaning, they have had experience with the tides. To me, it is worse to teach misleading explanations than to teach none. To me, one of the basic tenets of the scientific method or attitude is accuracy and when we forsake that, we defeat by our method one of the aims of science teaching.

Another definition, or a clarification of definitions, we need to make is the term that we are to use for the science that is taught in the elementary school. For several years there has been a quibbling over terms that to me seems a waste of time and paper space. I refer, of course, to the question as to whether the term "elementary science" or "nature study" should be used. Even in the 1947 Yearbook of the NSSE there is a paragraph about the use of the two terms. As far as I can see, it is in no way basic to the teaching of science and is an example of the term-quibbling that can so often be found in education publications and at times makes me almost ashamed that I am in the field! Whatever the name, science can be taught.—A rose by any other name—. The advantage to the use of the term elementary science at the present is that it is the term in more popular use. The condemnation of nature study in the 1947 Yearbook fails to consider that what has been taught as nature study for many years is not the same as their definition of the term. Nature study, as it has been taught, included all the phases of the natural phenomena, what more can science include. Of course, the subject has gone through many phases,— its growing pains—as does everything else. Many ideas were tried, some good, some bad. The good ones were kept and the bad ones eventually dropped. The only reason that elementary science does not have the same record is that it is too new a term. When it was introduced, it took over what had been learned in the teaching of nature study, thus avoiding some of the early mistakes. It in turn will make other mistakes that at some future time may make another name desirable to some people. The limitations so often applied to nature study are to a large extent imposed by those who would condemn it, not by those who recognize the value of the growth and early experience in the field. So if I use the two terms interchangeably, you will understand that to me they are the same.

Having stated my definitions, whether or not you agree with them, let us consider why we should include science in the education of the American people. In the 1947 Yearbook I find this statement:

"In science lies man's hope for his continuous and progressive welfare. It is for this reason, fundamentally, that science justifies, even demands, a prominent place in the school program."

I can agree to that statement if we include the social sciences. But if science is to be limited to the areas that I used in the previous definition, I will have to say that the statement is a little too broad. Particularly since the dropping of the atomic bomb, there seems to have been an increasing suggestion that the trouble with the world is that the sciences have gone too fast in their development for the social studies to keep up, that there should be a moratorium on science until we can learn how to use what we know. That becomes the field of social science. I am not saying that science does not have a part to play in that adjustment that must be made, but I am saying that the social sciences have a larger part to play unless there is more emphasis on the relationship of science to society than there has been in the past. When that happens, we will be accused of entering the field of social science. Personally I think that is what we need. For too long there has been too much emphasis on the subject matter fields as being mutually exclusive. If we are to meet the needs of society, we are going to have to put more emphasis on the interrelationships of the areas, and cease being jealous competitors for the student's time and interest. In the same yearbook we find this statement, which in a way says the same thing:

"Science is today on a plane of high significance and importance. It is no longer, if indeed it ever was, a mysterious and occult hocus pocus to be known only to a select few. It touches, influences, and molds the lives of every living thing. Science teachers have a great responsibility to make a large contribution to the welfare and advancement of humanity. The intellectual aspects of this responsibility are at least equal in importance with the material. Science is a great social force as well as a method of investigation. The understanding and acceptance of these facts and this point of view and their implementation in practice will more than anything else make science teaching what it can and should be."

Again to quote Dr. Conant:

"One of the objects of the Terry Foundation (for which the lectures that make the book were originally prepared) is 'the assimilation of what has been or will be hereafter discovered, and its application to human welfare.' I like the word 'assimilation,' its use in connection with science at once brings to mind one of the unsolved problems of this age. Is it not because we have failed to assimilate science into our western culture that so many feel spiritually lost in the modern world? . . . When what we now roughly designate as science has been fully assimilated into our cultural stream, we shall perhaps no longer

use the word as we do today. When that time arrives, as I have no doubt it will, the subject of this book will be fused into the age-old problem of understanding man and his work: in short, secular education . . . .

"My argument, therefore runs as follows: we need a widespread understanding of science in this country, for only thus can science be assimilated into our secular cultural pattern. When that has been achieved, we shall be one step nearer the goal which we now desire so earnestly, a unified, coherent culture suitable for our American democracy in this new age of machines and experts."

It is new to find such interest in the general public having an understanding of science on the part of such a man. It seems to me to be a reflection of the increasing interest in the education of the general public in science on the part of the people who are research scientists. I am sure that this group is aware of this increase in the past ten years or so. It has interested me to notice the increased interest in science teaching that is shown by the programs of the AAAS since I first began attending them about ten years ago. Then, there were scarcely any papers on science teaching outside of the meetings of the special groups of teachers, in fact there was no meeting of the NABT or the NSTA for there were no such organizations. Now the annual meetings have at least one panel or symposium on the teaching of science; the national organizations of science teachers have meetings of two or three days; and many of the organizations of one particular field of science have at least one session on the teaching of that phase of science. There seems to be a growing awareness of the importance of the teaching of science as well as of the research in science. I know of one university Math department which has recently hired a man part of whose job is the improvement of the instruction on the college level. When the universities will give promotions on the basis of outstanding teaching, as well as outstanding research, the recognition of the importance of teaching in the field will have been completed.

Probably many factors enter into the interest of the science specialist in the teaching of science. It would be outside of the range of this paper to try to analyze them. However, there are two that I would like to mention. First, I think that this interest is at least in part—shall I say—selfish. Too many students come into colleges with a lack of interest in science, if not an antipathy to it, at least partly because the previous teaching has been poor. Second, there seems to be an increasing recognition that the interest in science that may eventually make a specialist is usually developed before the student gets to college. Both of these put a large responsibility on the elementary and secondary schools as far as the continued supply of science specialists is concerned. But of course the elementary and

secondary schools have a much greater responsibility, that of giving the non-specialist some understanding of the work of the specialist, or some ability to understand and appreciate that work when it touches on the life of society as a whole.

All of this would seem to be sufficient justification for the inclusion of science in the elementary curriculum, but it is perhaps so indefinite that before the teacher can be effective, it is necessary to analyze these ideas to a little more definite values of science. What can science do for the life of the individual and for the society in which we must live? When any teacher, or group of teachers, has formulated the answer to those questions in the light of the students and the community, she is ready to proceed with a planning of the science curriculum.

In the 1947 yearbook of the NSSE the following are listed as the objectives of elementary science:

1. Functional understanding of information, concepts, and principles
2. Instrumental skills
3. Elements of the scientific method
4. Scientific attitudes

Perhaps I am being hypercritical when I say that those are fine, high-sounding objectives that offer little to the individual teacher who goes out to teach science in the elementary schools with a minimum of training and with supervisors who are not particularly interested in science. My freshman class in nature study is composed of students who are going out to be elementary teachers with one or two years training. They know very little about the world about them, about any of the sciences. Many of them have had no science in elementary or high school, except what they may have gotten in a required health course. More of them have had a ninth grade course in general science than in any other science. I am amazed every term at the ignorance of some of them about what to me, seem the most elemental science knowledges and concepts. They take five-term hour courses in biological science, physical science, and geography and three-term hour courses in health education and nutrition for children. In those courses we teach them all that they will get of the subject matter of science and of the teaching philosophy and techniques. For this group, and throughout the country the elementary teachers with this type of training are in excess of those with an adequate training, to teach science is a disagreeable chore that they will avoid when possible. For this group, the objectives of the 1947 yearbook are so many useless words.

In my classes I have finally come to spending at least one period

with them in trying to work out a statement of what science can do for the student in the elementary school in words of one syllable that can have meaning for them. With different groups we reach somewhat different statements, but we use two main headings: What can a knowledge of science do for the individual? and, In what ways has science influenced the world in which the individual must live? Of course there is overlapping and interdependence between the two headings but they do help to clarify the thinking of the students.

Under the first heading I usually begin with the suggestion that they start by analyzing what science knowledge has influenced their own lives. I wonder what results I would get if I asked the same question here! With the classes, I usually get very few suggestions at first. Then as we start, ideas are suggested by the ideas of some of the other members of the class until we finally arrive at some organization for the many and diverse ideas presented. I get somewhat the same results by asking what they would like to have included in the course, since we cannot cover all of the phases of biology we might as well cover those about which they have some curiosity. It is the rare class that will have enough knowledge of what can be done to know what they would like to do. They know what has been done in previous years and that is about the extent of their suggestions. In most classes we come finally to about this list of ideas of what a knowledge of science can do for the individual, in about this order:

1. It can make life more interesting because it can give an aquaintance with the environment.

2. It can satisfy the natural curiosity of the individual about the world in which he lives, can offer an explanation of the forces that operate in the world to make it what it is.

3. It can help the individual overcome his fear of the world about him and rid himself of superstitions.

4. It can stimulate the development of cause-and-result-relationship thinking and thus help to overcome prejudices.

5. It can develop some understanding on the part of the individual of what has and has not been done in science and possibly why some of the problems are still unsolved, why we so often have to say "that is just the way things behave."

It always surprises me that so many of the questions asked in the classes deal with the first statement. The students still are more interested in what things are than in almost any other phase. This has been a part of elementary science for as long as it has been taught, even in the days when it was called nature study. Yet these college freshmen do not know some of the commonest forms of plants and animals. During this term, I have had students ask if the civet cat and the skunk were the same; if the woodchuck and the groundhog

were the same. They have been surprised to find that there are more than one kind of maple or elm. These are things that even primary grade children can learn, but at present we are not doing an effective job of teaching acquaintance with the world of plants and animals. This may not a be part of science that is necessary to survive in this day of city civilization, but it does make the individual more at home in the world. In addition to the plants and animals, the acquaintance with the environment should extend to the physical world, to the weather and its causes, to the soils and their conservation, to the rivers and their power, to the uses of the power that is available in the world, steam, hot air, electricity. These latter phases of the environment are more complex in many ways and probably should belong in the upper grades, but they are a part of the acquaintance with the environment that can make life richer and more interesting.

Every person has some fear of the unknown. Anything that can help the individual become acquainted with the things of the world, will help the individual to overcome that fear. The unknown and the fear of it has led to the development of superstitions as explanations. Science in so far as it offers explanations of the world about the individual helps to overcome superstition.

One of the aims of science at almost all levels is the development of the scientific method. It is sometimes doubtful whether it is possible for all people to really develop the use of the scientific method. Perhaps what we really want is the development of a scientific attitude, an attitude of questioning propaganda, of withholding decisions until the facts are presented, of thinking with facts rather than prejudice. If we would develop a citizenship with these qualities, we would have made a great contribution to the society of America. Many subjects have some claim to developing this attitude, but it seems to me that the sciences can do it most adequately. My classes find the rather awkward, but descriptive term "cause-and-result-thinking" of more meaning for them than the term scientific method or attitude.

The fifth point, an understanding of what can and cannot be done in science, is of value to put science in the realm of the everyday individual, out of the realm of the supernatural. Many people seem to think that science can answer all of our questions, and are disappointed and lose faith in the ability of the scientists when for some reason it is impossible. We need an appreciation of the place of pure research in society, a realization that even though there seems to be no immediate use for the studies being made, the more we know about our world the more completely we can control it. So there should be an encouragement of the basic research, not just the technological applications of the discoveries that have been made in the past.

As to the influence of science on society, some of the factors are obvious. The classes for whom this is an exercise usually list:

1. It has led to great technological applications and developments that make the life of today very different from that fifty years ago, as with electricity, radio, the airplane, automobiles, and many of the other things that we take for granted but to many people of the world are luxuries.

2. It has presented some explanations of natural phenomena that are influencing the thinking of educated people, as the laws of inheritance, the evolutionary development of plants and animals, and the release of atomic energy for weapons.

These are obvious and need no further amplification. I am sure that each of you could supply many more examples of the influence of science on society.

Having considered what science is and what it may do for the individual and society, can we determine the place of science in the elementary school? Perhaps I am partial, but it seems to me that science has as much to offer to the average person as any of the other special fields. It has a place in the education of people that nothing else can fill entirely. However, it cannot answer all of the needs of the individual or society. Science needs a place in the curriculum as large as the teachers can make it without sacrificing the values to be derived from other subjects. That seems an ambiguous statement with little meaning. In a way it is. I am attempting to say that science should not try to take all of the teaching of the individual but should cooperate with the teachers of other subjects, especially the social studies, in the development of a citizenry that will have an understanding and appreciation of science and of its application in the society of this country.

AIDING OUR ENEMIES

Advocates of alien ideologies find strong, potential allies in such threatening circumstances as the following within the United States:

—five million children were without opportunity of becoming well grounded in the foundations of American life because they were not in school at all according to the U. S. census of 1940.

—some communities in some states in 1940 spent 60 times as much for the education of a child as did some other communities in other states.

—ten million adults in 1940 had so little schooling as to be almost illiterate.

—three million of this number had never been enrolled in any school.

—25 per cent of our people over 25 years of age in 1940 had six years or less of schooling

—educational neglect caused Selective Service in World War II to reject the equivalent of 20 combat divisions, almost as many combat divisions as were deployed in the entire Pacific area during the war.

WHAT IS SCIENTIFIC METHOD?

NORMAN LOWENSTEIN
James Madison High School, Brooklyn, New York

1. THE PROBLEM AND ITS EDUCATIONAL SIGNIFICANCE

A fundamental aim of science teaching in high school and college is to develop in the student the mode of thinking which is characteristic of the scientific method. For this purpose, expensive equipment has been furnished to the schools and much time is devoted to laboratory work. Consequently, it is a matter of great importance that the nature of scientific method be clearly understood by teachers of science; otherwise, this expenditure of time, effort, and money is not likely to be fruitful.

Unfortunately, the question, "What is scientific method?" is as difficult as it is important. The scientific mind cannot be observed in action. Moreover, the scientist himself rarely stops to analyze his own thought processes as he probes the secrets of the universe. His interest, of course, lies in the results of his thinking rather than in the thinking itself.

However, to many philosophers and logicians the question of the nature of scientific method has proved tempting because of its close connection with the more general problem of the nature and validity of all human knowledge. As a result, several very famous thinkers have advanced elaborate explanations of science and its method. A number of scientists, fortunately, have also expressed their thoughts on the subject. Although few have undertaken to formulate a complete philosophy of science, the casual remarks of famous discoverers are sometimes extremely significant.

In order to maintain clear objectives throughout this discussion, it may be useful to restate the problem in the form of five specific key questions:

1. What is the nature of scientific knowledge?
2. How does scientific knowledge originate?
3. What is the role of deduction in science?
4. What constitutes verification in science?
5. What is an experiment?

2. WHAT IS THE NATURE OF SCIENTIFIC KNOWLEDGE?

Science is essentially an organized system of concepts. However, since any body of knowledge consists of interrelated concepts, the question arises, "What distinguishes science from other systems of concepts?" For example, what is the difference between science and common sense?

In the first place, the concepts of science are nearly always clearer than those of common sense. That is to say, in science, a concept not only has more associations but these relationships are always stated with the greatest possible precision. For example, facts, which are very definite, observable relationships, are always expressed, if possible, in quantitative terms as a result of careful measurement. Similarly, a principle, which is a more general and less certain relationship, is stated, whenever possible, in the form of a mathematical equation or formula. Finally, even theories, which are more or less tentative relationships between very general concepts, are formulated with as much precision and clarity as the scientist's understanding of the universe will allow. In short, we find in science a *conscious attempt to be clear* which is seldom found in common sense.

Secondly, no inconsistency is ever tolerated in science as is only too often the case with common sense. If the relationship established by certain newly discovered facts flatly contradicts an accepted principle or theory, the generalization is either modified to square with the facts or it is abandoned. Similarly, if an hypothesis conflicts either with a number of facts or with a well established law, it is revised or replaced by some other more consistent hypothesis. It should be noted that not infrequently what was thought to be a fact must be amended when a check-up reveals an error in observation or measurement. In any case, the very life of science demands that there be logical consistency in its web of relationships.

Finally, science has a vastly wider experience and therefore its conceptual pattern comprises many more relationships than that of common sense. Scientific knowledge is a result of the conscious cooperation of many intellects and, consequently, its experience is composite. Moreover, scientists are continually searching for new relationships with eyes and ears tremendously sharpened and extended by such instruments as the microscope and telescope. As a result entirely new fields of experience have been opened to the human mind.

3. How Science Originates and Grows

The gradual growth of scientific knowledge, its constant change in texture as the experience of science widens, is comparable in many respects to the development of an organism. Dr. Frederick Barry, a calorimetrist of note, makes this analogy in his illuminating book, *The Scientific Habit of Thought.*

"Meanwhile, however, our knowledge of that which is comprehensible—our knowledge of phenomena—our science grows: not like a crystalline aggregate, by the precipitation, partial dissolution and redisposition of invariable elements of fact: but like a species of or-

ganism by the continual proliferation, absorption, destruction, regeneration, and readjustment of its elementary parts, in functional activity; and at longer intervals by variation and mutation, approaching perhaps a final stability of form. The analogy is imperfect, but its imagery may serve. Not impossibly, it is something more than an analogy. Scientific knowledge reflects the effort which produces it, an effort born of the struggle for life: it is vital; organized."[1]

The organic nature of this growth of science implies that every new concept formed in the system is a clarification, that is, an extension or a correction of some preceding concept. The question, "How does the first concept originate?" which may be raised at this point is clearly irrelevant to this discussion. We are concerned with the origin of *scientific* ideas which, of course, come into being long after the first concept has been formed. That is to say, the first discoverers in any science have never been infants and, therefore, were invariably in possession of a large body of concepts when they started their researches. Therefore, since scientific knowledge has always developed from nonscientific knowledge, the significant question is, "From what previously existing conceptual systems does science spring and how does this transformation take place?"

It must be obvious that one great source of scientific concepts is common-sense or everyday, practical knowledge. This fact has been noted by many philosophers and scientists. For example, Prof. John Dewey makes this observation, "The astronomer, chemist, botanist, start from the material of gross unanalyzed experience, that of the "common-sense" world in which we live, suffer, act and enjoy; from familiar stars, suns, moons, from acids, salts and metals, trees, mosses and growing plants."[2]

Another fundamental source of scientific concepts, which is some times overlooked today even by scientists themselves, is philosophy. One scientist who has noted this important fact is Dr. Barry. "Now, the historian of science, on the basis of his record, is compelled to admit that, whereas the sharpest and most primary concepts of science have been inferred directly from experience, her broadest generalizations, those which supply the greatest framework of her conceptual structure, have all without exception been supplied her, not always as vague suggestions but in more than one instance as matured theories, by speculative philosophy. . . . Speculative philosophy is the mother of theoretical science: the fact cannot be controverted by the most obstinately myopic of progressive thinkers."[3]

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[1] Frederick Barry, *The Scientific Habit of Thought*, New York, Columbia U. Press, 1927, p. 158.
[2] John Dewey, *The Quest for Certainty*, New York, Minton, Balch, 1929, p. 173.
[3] Frederick Barry, *The Scientific Habit of Thought*, New York, Columbia U. Press, 1927, p. 68.

Such general concepts as atom, force, attraction, repulsion, element, evolution were all at one time purely philosophical notions.

In point of fact, the early scientists were, almost without exception, philosophers and hence, science, even as late as the middle of the last century, was frequently referred to as "Natural Philosophy."

We are now in a position to give a direct answer to the focal question, "How does scientific knowledge originate?"

Since the very groundwork of science demands precision in the statement of factual relationships, a fundamental step in the construction of a science consists in checking up the observations of common sense and clarifying its concepts by analyzing and measuring the relationships involved in gross phenomena.

Almost simultaneously with this clarification of specific relationships there takes place a process of transforming general ideas derived from common sense and more often from philosophy into scientific generalizations which serve to illuminate the facts. That a change in general concepts should accompany the reorganization of factual relationships is seen to be inevitable in the light of the close interdependence of concepts in any system of knowledge. Moreover, this process is no less vital to the growth of science than is the clarification of facts. Helmholtz remarks in one of his lectures, "It is not enough to be acquainted with the facts; scientific knowledge begins only when their laws and their causes are unveiled."[4]

This distinction between the clarification of facts and the reorganization of ideas in science is noted by Prof. John Dewey who says, "Then the process of investigation divides into two kinds of operations. One is that of careful and analytic observation to determine exactly what there is which is indubitably seen, touched, and heard. . . . The other operation consists in searching through previous knowledge to obtain ideas which may be used to interpret this observed material and to suggest the initiation of new experiments."[5]

The close interconnection between these two scientific operations cannot be overemphasized. Indeed, the only basis for separating them at all is the fact that in some investigations the *primary* purpose is to analyze gross phenomena whereas in others the *chief* objective is to test certain proposed laws or theories. Consequently, although this difference in point of view make it necessary to discuss each process apart from the other, their actual interdependence should be kept in mind.

4. Scientific Analysis of Phenomena

Science is often thought of by the layman as being a collection of

[4] H. Helmholtz, *Popular Lectures*, translated by E. Atkinson, New York, Appleton, 1873, p. 13.
[5] John Dewey, *The Quest for Certainty*, New York, Minton, Balch, 1929, p. 173.

facts. Such a notion is easy to understand when we recall that the greater part of scientific research is primarily directed towards the clarification of factual relationships. A perusal of research periodicals like the *Physical Review*, *Chemical Review*, or *Biological Abstracts* will reveal the truth of this statement. How, then, does the scientist proceed in making an analysis of complex phenomena?

It must be emphasized that research of any kind is never purely random or trial-and-error behavior. This follows from this principle that once a conceptual system has been started, all phenomena, no matter how intricate, receive an interpretation of one kind or another in the light of concepts already formed in the mind. Consequently, the investigator always approaches the situation, which he is about to analyze, with some preconception, however vague or uncertain, of the constituent elements involved.

It is perhaps significant that Herbert Spencer (1820–1903), although an ardent empiricist, recognizes this truth. "Little recognized as is the fact, it is nevertheless true that we cannot make the commonest observation correctly without before-hand having some notion of what we are to observe."[6] Henri Poincaré, a famous mathematician, makes a similar remark. "It is often said experiments must be made without a preconceived idea. That is impossible. Not only would it make all experiment barren, but that would be attempted which cannot be done. Every one carries in his mind his own conception of the world, of which he cannot so easily rid himself. We must, for instance, use language; and our language is made up of preconceived ideas and cannot be otherwise."[7]

Often these anticipatory concepts are clear enough to form definite working hypotheses which again emphasizes the fact that there can be no sharp line of demarcation between the process of clarifying facts and the process of reorganizing general concepts in science. Thomas Hunt Morgan, probably the foremost of American geneticists, tells us that "the carrying out of an experiment implies the formulation of a working hypothesis, and this usually presupposes some knowledge of the possible conditions that control the phenomena. The experimental work becomes more explicit and accurate the more we know beforehand of the possible conditions that may enter into the result. The ability of the experimenter is shown by this insight into the possible factors that may be present."[8]

The actual analysis of phenomena, is conducted in one of two ways: (1) by comparing various chance observations or (2) by making a controlled experiment which is really a more lucid and reliable way of

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[6] Herbet Spencer, *Essays*, New York, Appleton, 1916, vol. 11, p. 164.
[7] Henri Poincaré, *Foundations of Science*, translated by F. Halsted, New York, Science Press, 1913, p. 129.
[8] T. H. Morgan, *Experimental Zoology*, New York, Macmillan, 1910, pp. 9–10.

comparing observations. The difference between these two procedures is clearly stated by Prof. John Dewey.

"There are two methods for varying conditions. The first consists in comparing very carefully the results of a great number of observations which have occurred under accidentally *different* conditions.

"This method of analysis by comparing cases is, however, badly handicapped; it can do nothing until it is presented with a certain number of diversified cases. . . . The method is passive and dependent upon external accidents. Hence the superiority of the active or experimental method. Even a small number of observations may suggest an explanation—a hypothesis or theory. Working upon this suggestion, the scientist may then *intentionally* vary conditions and note what happens."[9]

The essence of an experiment, then, is control of the phenomena. This procedure is described by Dr. Abraham J. Goldforb, a well-known zoologist, as follows:

"The new era in science demanded experimentation, i.e., the determination of the immediate or proximate mechanistic cause or causes of the phenomenon. The scientist started with observations or facts. He then devised an experiment in which the profoundly complex conditions associated with a phenomenon were reduced to constancy or were known. Only one condition or factor was unknown. The experimental conditions differed from the control conditions by this one, simple or compound, unknown factor. The object was to determine the role of this unknown or x in the phenomenon."[10]

5. The Origin and Development of Scientific Theories

The first step, of course, in the transformation of concepts consists in the formation of a definite hypothesis which is nothing more than a tentative rearrangement of the conceptual structure and is, therefore, conditioned by the state of development of this structure. As the philosopher, George Henry Lewes, aptly remarks, "Guessing is only fertile in proportion to the fertility of the experiences it reproduces. If a man knows little, he can infer but little."[11] A great physicist, John Tyndall (1820–1893), describes the formation of hypotheses in the following illuminating passage: " . . . from a starting point furnished by his own researches, or those of others, the investigator proceeds, by combining intuition and verification. He ponders the knowledge he possesses, and tries to push it further, he guesses, and checks his guess; he conjectures, and confirms or explodes his conjecture. These guesses are by no means leaps in the dark; for knowl-

[9] John Dewey, *How We Think*, New York, Heath, 1910, pp. 150–151.
[10] A. J. Goldforb "Medical and other Sciences" *Science*, January 24, 1930, vol. LXXI, no. 1830, p. 78.
[11] G. H. Lewes, *Problems of Life and Mind*, Boston, Osgood, Boston, 1874 p. 31.

edge once gained casts a faint light beyond its own immediate boundaries."[12]

There is, of course, a high probability of error in the formulation of hypotheses. As Jevons points out, "It would be a complete error to suppose that the great discoverer is one who seizes at once unerringly upon the truth, or has any special method of divining it. In all probability the errors of the great mind far exceed in number those of the less vigorous one. Fertility of imagination and abundance of guesses at truth are among the first requisites of discovery; but the erroneous guesses must almost of necessity be many times as numerous as those which prove well founded. The weakest analogies, the most whimsical notions, the most apparently absurd theories, may pass through the teeming brain, and no record may remain of more than the hundredth part."[13]

For this very reason, one of the most important and, in fact, an absolutely indispensable step in science is the verification of hypotheses. By verification is meant nothing more than the testing of alternative hypotheses for consistency with the entire conceptual system including the exceptional facts which initiated the search for a new theory. Dr. Barry describes the process of verification as follows:

"A scientist hypothesis is always verified in two ways. It is tested first of all for consistency with the rest of our experience in thought, that is, metaphysically, in the ancient manner. As a consequence of the sharp definition and clean-cut correlation of all our basic scientific conceptions, this procedure, which is logical, may now usually be much abbreviated; . . . . Its necessity, however, is obvious; and the consistency of new formulations with those which are generally accepted is always established before they are seriously considered, excepting in the rarest instances, and then only for sufficient reasons.

"This done, the hypothesis must be tested for its consistency with the rest of experience, in the world of events. This critical verification which alone can establish complete consistency may sometimes be made directly. More frequently, however, since the hypothesis naturally embodies suggestions which are not directly inferable from the facts already known, it must, before this is possible, be deductively transformed: that is its implications must be worked out logically until some of these present themselves in the guise of statements of observable fact."[14] Here we have the answer to the third key question; namely, "What is the role of deduction in science?" Deduction by revealing the relationships implied in an hypothesis enables the

[12] John Tyndall, *Fragments of Sciences*, New York, Appleton, 1871, p. 110–111.
[13] W. S. Jevons, *Principles of Science*, New York, Macmillan, 1875, vol. II, p. 221.
[14] Frederick Barry, *The Scientific Habit of Thought*, New York, Columbia U. Press, 1927, pp. 109–110.

scientist clearly to determine whether or not the supposition is consistent with experience since all that is then necessary is a simple comparison of its implications with the facts. Consequently, as Dr. Barry goes on to say, "This deductive elaboration of hypothesis is clearly a very important procedure. In physical sciences usually, and always whenever the hypothesis may be exactly formulated, it is carried out mathematically. The role of mathematics and more generally that of formal logic in natural science is thus explicitly defined. The power of these instruments of research is tremendous. By revealing the remotest implication of every conception which they elaborate they completely ensure the conceptional consistency of the whole scientific synthesis. . . . "[15]

Having deduced the implications of alternative hypotheses, the scientist is ready to marshal the relevant facts. Sometimes most of these will be on hand but more often the facts must be secured by making new observations or experiments. Once more, then, we see the interaction of general concepts and facts. New facts lead to revised general concepts and the revision of concepts in turn inspires the search for new facts.

When all the available facts substantiate the implications of an hypothesis, it becomes a scientific law or theory. If, on the other hand, any or all of these deductions are contradicted by the results of careful observation or experiment, a new hypothesis or, more frequently, a modification of the old one is advanced and the whole process of verification is repeated. Hence, as Dr. Myron L. Ashley remarks, "The activity of experimental verification is not only a testing, a confirming or weakening of the validity of an hypothesis, but it is equally well an evolution of the meaning of the hypothesis through bringing it into closer relations with specific data not previously included in defining its import."[16]

In science, two or more hypotheses are nearly always suggested simultaneously in explanation of the same set of phenomena. The deductive elaboration of these different suppositions, if carried far enough will result in several conflicting or alternative implications. Obviously, if an experiment can be devised which will reveal the facts relevant to the issue, the most tenable hypothesis can be determined by the elimination of all the others. Sir John Herschel comments upon the scientific importance of such a crucial experiment. "When two theories run parallel to each other, and each explains a great many facts in common with each other, any experiment which affords a crucial instance to decide between them, or by which one or the other

[15] Frederick Barry, *The Scientific Habit of Thought*, New York, Columbia U. Press, 1927, p. 110.

[16] M. L. Ashley, "The Nature of Hypothesis," *Studies in Logical Theory*, edited by J. Dewey, Chicago, Chicago U. Press, 1903, p. 182.

must fall, is of great importance."[17] This procedure, in fact, is the only means of establishing a logical presumption in favor of one hypothesis rather than another and is, therefore, indispensable in scientific verification.

6. The Answers to the Five Key Questions

In summarizing the foregoing description of science and its method, we may perhaps at this point suggest a brief but definite answer to each of the five key questions which were formulated at the outset of this study.

(1) What is scientific knowledge? Scientific knowledge is a system of concepts. It differs, however, from common sense in (a) the clarity of its concepts and the precise formulation of their interrelationships, (b) its rigorous, logical consistency, (c) the tremendous scope of experience which it represents.

(2) What is the origin of scientific knowledge? The initial facts of a science are common-sense observations which have been checked up and rendered precise. New factual relationships are discovered by this same process of analyzing gross phenomena which consists in making a careful comparison of observations or, better still, by devising a controlled experiment. The discovery of new factual relationships, by revealing crucial exceptions to accepted generalizations, initiates a reorganization of ideas. As a result, the philosophical or common-sense notions with which science begins are revised and extended until an apparent consistency with the rest of experience is secured. This equilibrium, however, is continually disturbed as the experience of science widens, with the result that further conceptual changes necessarily take place. A new theory always makes its debut as an hypothesis formulated in the light of past knowledge.

(3) What is the role of deduction in science? In order that an hypothesis may be tested, it must first, as a rule, undergo extensive deductive development so that its implications may be compared with actual observations. Deduction, therefore, is really the first step in verification since it prepares the hypothesis for its experiential test.

(4) What is meant by verification in science? The entire process of testing alternative hypotheses for consistency with the facts is known as verification. The relevant facts, if not already known, are determined by careful observation or preferably by controlled experimentation. All hypotheses which are inconsistent with the factual relationships in nature are discarded or else revised and retested.

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[17] Sir John Herschel, *Preliminary Discourse on the Study of Natural Philosophy*, London, Longmans, Green, 1830, p. 206.

Clearly, then, verification is the means whereby scientific knowledge is cemented into an integrated system.

(5) What is an experiment? In the first place, an experiment always involves the trying out or testing of some preconception which may range from a vague notion to a definite hypothesis. A second characteristic, the "control," enables the investigator to determine the precise effect of a single factor. Cautious observation, particularly in the form of the controlled experiment, is the means whereby known facts are rendered precise and new relationships discovered. Experimentation, therefore, is chiefly responsible for the vast experience of science.

7. Some Educational Implications

The hypothesis which has just been suggested as a tentative solution to the problem of this study has considerable educational significance especially with regard to the laboratory method of teaching science.

In the first place, it is clear that the student learning a science, just as the pioneers in science themselves, is engaged essentially in a process of transforming his common-sense concepts into a more accurate, more consistent and more extensive system of knowledge. The teacher of science, therefore, should try to set in motion in the classroom and school laboratory the same method of investigation which has been responsible for the very existence of science.

Since a change in the conceptual structure must usually be initiated by a widening of experience, a fundamental step in science teaching is the presentation of facts which cannot be satisfactorily explained in terms of the student's past knowledge. Which facts shall be presented must be determined by (1) the nature of the scientific concepts which the teacher wishes to develop in the student mind, and (2) the clarity and correctness of corresponding or related concepts which the student already possesses. The mere presentation of a host of irrelevant facts, although these may be logically organized within themselves, is a fundamental error. As Dr. Goldforb remarks, "To substitute the accumulation of facts and 'laws' or dexterity of manipulation for experimental methodology is naive, erroneous, anti-science, the cartoon of science."[18]

Consequently, besides clear objectives, the teacher must also have a *deep insight into the student mind*. In other words, he must be able to imagine himself in the place of the student. Needless to say, this is a very difficult feat which is further complicated by the fact of individual differences. Its accomplishment clearly demands that the teacher become acquainted with his pupils as quickly and as thor-

[18] A. J. Goldforb, "Medical and other Sciences," *Science*, January 24, 1930, vol. LXXI, no. 1830, p. 79.

oughly as possible. Careful questioning during class discussions and and in the laboratory is, therefore, of paramount importance.

Once the teacher is familiar with his students' concepts, the presentation of the right facts is a comparatively simple matter. This can be done by means of appropriate objective material, references to books, and demonstration experiments. In actual scientific research, of course, these facts are always discovered in the course of lengthy experimental analyses. But since the object of science teaching is not so much to develop expert laboratory technicians as it is to change concepts and since fact finding is a laborious and time-consuming process, most of the relevant facts are better presented directly and perhaps also more dramatically.

Provided the teacher has not misjudged his pupils the facts presented should reveal to them a number of disturbing exceptions to certain of their accepted beliefs. Even the least vigorous intellects in the classes will eventually make efforts to revise or extend these concepts. Such attempts to restore equilibrium in the conceptual structure will take the form of hypotheses or guesses. The job of the teacher at this point is to encourage hypotheses which evidence careful thought and to discourage wild, random guessing. Encouragement here, of course, does not mean acceptance of any particular hypothesis. The hypotheses which have been advanced must next undergo careful deductive development. "*If* this supposition is true, what would the facts *have* to be?" is the question which must be answered. When a number of implications have been derived in this way, the final step is to marshal the relevant facts for a crucial comparison with these deductions. Sometimes the facts needed for this process of verification are available. More often, however, laboratory experiments are necessary. Although, under certain conditions, these may be suggested and even performed by the teacher, whenever possible, experiments should be devised and executed by the students themselves. Otherwise, the true significance of an experiment is likely to be only vaguely understood by the student. Needless to say, the control is a vital part of the experiment. When an hypothesis has been verified by careful observation and experimentation, it is tentatively accepted. In the course of this laboratory work new facts may be disclosed which will disturb other ideas and which consequently will lead to other hypotheses and experiments.

It is evident that laboratory manuals have no place in such procedure since the experiments to be performed by the students must not be rigidly standardized. The hypotheses advanced in different classes will rarely be exactly the same. In fact, whenever possible, the laboratory method would demand the formulation and verification of hypotheses by the individual student.

JAPANESE REPARATIONS AND PHILIPPINE RECONSTRUCTION

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This is a turbulent period in the Philippine Islands. The Filipinos are faced with reconstruction and rehabilitation as a result of the war and Japanese occupation and at the same time must solve the problems attendant to the transition from a commonwealth to a new nation. To provide assistance during this period of economic reconstruction and political transition the United States government passed in April, 1946, the Philippine Trade Act (Bell Bill) and the Philippine Rehabilitation Act (Tydings Bill). Both are very helpful and the Philippine government is deeply appreciative of them. But are there not other possibilities of outside assistance? Japanese reparations, for example?

Reparations from Japan are being and are to be assigned to those war damaged areas of Pacific Asia that can use them. According to the Pauley Report, plants and equipment recommended for removal from Japan include: arms and munititon plants, and all plants making synthetic rubber, aluminum, and magnesium; substantial removals of blast furnaces, rolling mills, ferro-alloy plants, industrial explosive and chemical plants, power plants, and shipyard facilities; and some commercial shipping, machine tools and tool plants, and plants manufacturing heavy electrical machinery, copper, railway equipment, and telecommunication facilities.[1] Many of these items will be of little or no value to Philippine economy because the Islands have inadequate fuel resources and because there is no established steel industry. Even though there is a major iron ore field on Mindanao and considerable amounts of some of the alloy metals (manganese and chromium) elsewhere in the Islands, the lack of coking coal will retard, if not prevent the development of a significant iron and steel industry and hence those industries that may be dependent upon it.

However, a few of the items listed for removal can be used effectively in the Philippines, either immediately or within the next few years; specifically, commercial shipping, railway equipment and plants, machine tools, generators and other power equipment, iron and steel plants to supply local needs, and shipyard facilities. For example, commercial shipping for interisland traffic and railway rolling stock, if of the proper gauge, is needed badly.

There is also an immediate need for small machine tools to replace those destroyed, removed, or worn out during hostilities; especially

[1] *Dept. of State Bulletin*, Vol. XV, 1946, p. 597.

tools that can be used in railway repair shops, shipyards, foundries, and the machine shops of mining companies, sugar centrals, and the principal manufacturing plants. Additional tools and related equipment can be absorbed easily within the next few years as new industries are established, new mines opened or old ones re-opened, or as transportation service and public utilities are expanded and require additional construction and repair facilities.

Power plants are needed for both replacement and expansion, although it is doubtful if any sizeable power plant can be effectively moved from Japan to the Philippines. Since the Islands have a high hydro-electric potential and very limited fuel resources, generators and other equipment for hydro-electric plants will be of greater value than similar equipment designed for thermal units. Private diesel plants have been used widely in the Philippines in the past and their replacement by steam plants would be impractical in most cases, especially in the more mountainous sections where transportation costs are a vital factor. Steam plants that can be converted to diesel use may be a distinct possibility, however. A large thermal plant, for standby purposes, in the Manila area and somewhat smaller ones at Iloilo and Cebu probably represent the immediate major needs.

An iron and steel industry to supply the local market is highly desirable. This industry should use hydro-electric energy as widely as possible, partly because the island of Mindanao has the greatest iron ore reserves and also one of the two largest potential hydro-electric sites. There are vast areas of virgin forest, hence charcoal, rather than imported coal or coke, probably should supplement electrical energy in the manufacture of pig iron. Therefore, electric furnaces and small furnaces that can be adapted to the use of charcoal will be of greater value than blast furnaces and associated installations, even if it were feasible to move blast furnaces. Specific immediate needs include small electric steel furnaces (two or three-ton capacity) for foundries.

The ship repair facilities of the Philippines were to a large extent destroyed and those that remained were badly worn or damaged. Hence, the Islands can immediately utilize facilities suitable for the repair of small vessels of all types or for the construction of wooden ships. Cranes and other hoisting equipment, marine railways, and tool or engine shop equipment are within this category. If and when a significant steel industry becomes a reality, although that will probably be several years, the utilization of equipment for the construction of steel craft of a size suitable for interisland and coastwise shipping is quite possible.

EASTERN ASSOCIATION OF PHYSICS TEACHERS
ONE HUNDRED SIXTY-SEVENTH MEETING

JOINT MEETING WITH NEW ENGLAND ASSOCIATION OF BIOLOGY TEACHERS AND THE NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

Harvard University, Cambridge, Massachusetts

Saturday, December 13, 1947

Morning meetings—Littauer Hall

9:45 A.M. Greetings—Dr. Fletcher C. Watson, Assistant Professor of Education, Harvard School of Education

10:15 A.M. "Science Talent Search Winners," Miss Nancy A. Durant, Radcliff College

11:00 A.M. Panel on Value and Place of Science Fairs
Mr. William O. Brooks, Springfield Technical High School. Springfield, Mass.
Dr. R. K. Carleton, Rhode Island State College, Kingston, R. I.
Mr. John Gibbons, Brighton High School, Brighton, Mass.

12:00 M. The Scientific and Social Significance of the Atomic Energy Projects, Dr. Charles D. Coryell, Department of Chemistry and the Laboratory of Nuclear Science, Massachusetts Institute of Technology, Cambridge, Mass.

1:00 P.M. Luncheon, Harvard Faculty Club

Biology Group, Irving C. Keene, President, meets at the Harvard Biological Laboratories.

2:00 P.M. Business Meeting

2:15 P.M. Plant Growth, Dr. K. V. Thimann, Harvard Biology Department

2:45 P.M. A Class Demonstration in the Teaching of Health Education, Miss Betty Lockwood, Harvard School of Public Health

3:15 P.M. Inspection Tour of the Laboratories.

Chemistry Group, Dr. E. V. Lynn, President, meets at the Harvard Chemical Laboratories.

2:00 P.M. Business Meeting

2:15 P.M. Polarographic-Analysis, Dr. James J. Lingane, Associate Professor of Chemistry, Harvard University

Physics Group, Raymond F. Scott, President, meets at the Harvard Physics Laboratories.

2:00 P.M. Business Meeting

2:15 P.M. "Apparatus Committee," W. Roscoe Fletcher, Chairman, Bring the favorite "gee-gaw" from your bailiwick.

REPORT OF THE ONE HUNDRED SIXTY-SEVENTH MEETING OF THE EASTERN ASSOCIATION OF PHYSICS TEACHERS, HELD AT HARVARD, DEC. 13, 1947, TEN A.M.

Summary of the Talk by Dr. Fletcher Watson, Professor of Education at the Harvard Graduate School of Education.

In keeping with the theme of the joint meeting of the New England Biology Teachers Association, New England Chemistry Teachers Association, and the Eastern Association of Physics Teachers; the search for those with science talent; Dr. Watson made the following points:

1. There is need for only one science teachers organization not three as represented here. This one organization may well have three or more divisions in order to include all science teachers. There is much loss of energy because of the complete lack of unity in the efforts of the several organizations. With one organization all members would be working for a set of common purposes and thus more weight could be brought to bear where the weight is

needed. With one organization, officers would or could be of the best. Top flight people would fill these positions and lead the organization.

2. There is need for a higher level of scientific understanding in the voting public. Frequently the voters are called upon to register an opinion at the polls on the merits of efforts which involve the expenditures of thousands if not millions of dollars. An intelligent electorate is needed to choose wisely and since we do not have the best electorate it is a part of the work of science teachers to do their part in this most worthwhile endeavor.
3. In the United States we have a real need for a scientist backlog. This backlog is really very small at the present time and the Bush Report and Steelman Report indicate the real facts. As science teachers we have a real job to do. We must help increase this backlog.
4. For each boy and girl who goes to college there is one of equal potentially who does not. Whether that student is a potential science worker or not, there should be some kind of help so that the potential of the present nonattendant in college will not be lost. There is need for some type of subsidy to prevent the loss not only to the individual but also to society itself.
5. One effort, deserving of our utmost aid, is that of The New England Science Council. It is the plan of this organization to hold a New England wide science fair at which modest awards will be made to both pupil winners and their teachers. It is the plan to have local winners in cities, towns, and districts bring their exhibits to the New England wide fair. It is the hope of the Science Council that some worthy and potential worker will find a reward that will in some measure help him in continuing his science education. All schools in New England, public and private, secular and nonsecular, are cordially invited to take part in this most worthy effort in either an ultra simple or most elaborate manner. The final fair is to be held in Boston or Cambridge on May 14 and 15, 1948. Interested persons or organizations are asked to write to THE SCHOOL SCIENCE COUNCIL, 28 Newbury Street, Boston, Mass.

Report of the Science Talent Search Winners

Two winners of the Science Talent Search by Westinghouse were presented and spoke at the meeting. Each thanked the three organizations meeting at Harvard as representatives of the science teachers in the United States. They urged very strongly that everything possible be done to help all potential science workers. One is at Radcliffe doing graduate work in anthropology. She came to Radcliffe directly as the result of the Science Talent Search. The other is specializing in astronomy at Harvard. Both of these students have a history of great interest in science from the early grades and both are doing a splendid job at their respective institutions. They are most appreciative of the benefits they enjoy as a result of being connected with and winning awards in the Westinghouse Science Talent Search. The boy feels that many junior scientists are missed by this science talent search and that something should be done to rectify this condition.

Panel Discussion on the Value and Place of Science Fairs

Three speakers spoke at the panel discussion. Mr. Wm. O. Brooks of the Technical High School of Springfield, Mass., told the audience of The Technicade at Technical High School. He said that the main purpose of The Technicade is to get and hold the interest of both pupils and parents in science and demonstration. He feels that The Technicade has had great success. People numbering in the thousands come to see The Technicade which includes the class work and out of class activities in science at Technical High School. The Technicade also includes some commercial exhibits.

It is the belief of Mr. Brooks that the term science fair is really very flexible and that any and all endeavors, scientific in subject, may be called rightly a science fair. He would include assemblies, individual, curricular, and extracurricular activities, and research and semi-research projects on the part of the pupil.

Mr. Brooks gave examples of the latter by mentioning that students are given space in which to work at their projects. One student is working on spectroscopy and has built much of the apparatus. A second student is making a study of crystal growth, a third is doing some work in microscopy, and a forth has space to study weather and posts a weather map each day in the main corridor. Other individuals and groups are working at the present time in the following fields:

The study of latitude and longitude
Making of optical instruments
Building electronic equipment
Mineralogy in Massachusetts and Connecticut
Breeding of animals
Nutritional studies
Photography

The idea of a contest is not present at Teachnical High School but a contest would without doubt increase the number taking part as well as the interest in the whole program.

Dr. Carleton of the Rhode Island State College was the second speaker. He told the assembly of the great value and advantage of getting a sponsor for the program. He feels that the schools of Rhode Island have been singularly helped because a local newspaper provided publicity and financial aid. Dr. Carleton spoke of the many details of the fair and problems connected with judging.

Mr. J. J. Gibbons of the Brighton High School, Brighton, Mass., was the third speaker. He told the group of the Boston Science Fair which he directed last year. He spoke of the science fair as a "vehicle to get at the latent science ability."

The Scientific and Social Significance of the Atomic Energy Projects, Dr. Charles D. Coryell, Department of Chemistry and the Laboratory of Nuclear Science, Massachusetts Institute of Technology, Cambridge, Mass.

A very interesting illustrated lecture was given by Dr. Charles D. Coryell. He is well qualified to bring any group the most up-to-date information available on nuclear chemistry. Such general information is of value to the physics teacher as well as the chemistry teacher, as nuclear research requires the effort of both.

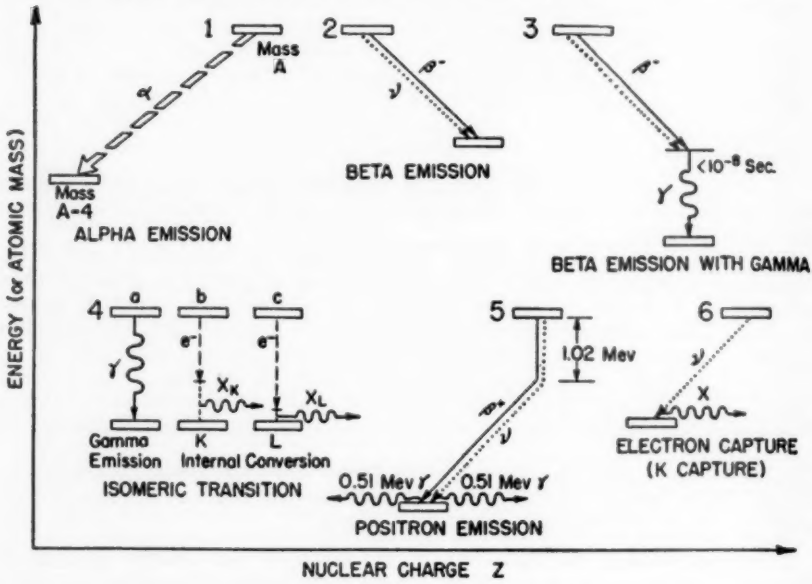
Much of Mr. Coryell's lecture concerned itself with the types of radioactive decay. There were six listed in the lecture:

1. Alpha emission
2. Beta emission
3. Beta decay with gamma emission
4. Isomeric transition
5. Positron emission and
6. Electron capture

The accompaning print of one of Mr. Coryell's slides illustrates the processes. (Permission to use the slide has been given to me by Mr. Coryell.)

1. ALPHA EMISSION: It is found only in isotopes of mass greater than 208. There is one exception, one isotope of Sm is a natural emitter of alpha particles.
2. BETA EMISSION: This is a very common type of radioactive decay. A small part of the energy is carried from the atom by means of the neutrino and does not yield any detectible ionization but frequently the nucleus is left in a metastable state. The nucleus is now conditioned to result in:
3. BETA DECAY WITH GAMMA EMISSION: This same type of emission may result from the unstable conditions set up by any of the other five types of radioactive decay.
4. ISOMETRIC TRANSITION: Here energy may be released in two ways, gamma emission and internal conversion. X-rays are emitted as a result of the expulsion of an electron from the K, L, or higher shells. There are some twenty cases in which decay by isometric transition has been observed. They have a half-life of from 10^{-6} seconds to 90 days.

5. Position Emission: Nuclei with an excess of nuclear protons readjust themselves to a more stable pattern. Positron emission occurs only where energy available is in excess of 1.02 million electron volts (m.e.v.).
6. Electron Capture: This is another method by means of which unstable nuclei achieve stability, X-rays are emitted and in nearly all cases of electron capture secondary gamma emission takes place.



Legend for the diagram:
α alpha particle
β beta ray
γ gamma ray
ν neutrino
straight, broken and wavy lines produce ionization.

From time to time in Mr. Coryell's lecture, the suggested new names for some of the elements were given. They follow:

Element 43 Technetium Tc
" 61 Promethium Pm
" 85 Astatine At
" 87 Francium Fr
" 93 Neptunium Np
" 94 Plutonium Pl
" 95 Americium Am
" 96 Curium Cm

Perhaps some may be interested in demonstrations in their physics classes involving the use of radioactive materials. Perhaps they have never done any demonstrating in the past because the source of radioactive agents was nonexistent. This is no longer true. Long life radioactive isotopes are now available for use in schools.

In speaking of some of the harms from the radioactive isotopes released in the cloud from the atomic bomb, Mr. Coryell said that the effects may be far reaching and we may not know about them for many years when the gradual changes brought about through genetics will show up.

He, like all of us, is not so much interested in the results many years from now

but in the harms to himself and his children. These harms not only come from the bomb but also from the fissionable material which may be by-products from our attempts to harness and use atomic energy. Where shall these by-products be stored? They cannot be thrown away.

Perhaps the danger from the bomb will be eliminated when man learns that on no matter what grounds are used, the final conclusion is "war is unsupportable."

Mr. Coryell drew attention to the following publications as they may be of interest to science teachers:

1. *Atomic Energy for Military Purposes*, H. D. Smyth, Government Printing Office and also Princeton University Press (1945); "This book was a best seller in 1945 and should be read by every person interested in military and industrial implications of atomic energy."
2. The fission product survey entitled, "Nuclei Formed in Fission: Decay Characteristics, Fission Yields, and Chain Relationships," issued by the Plutonium Project, *J.A.C.S.*, *68*, 2411–2442 (1945); "reprints of this may be obtained for thirty-five cents from the American Chemical Society, 1155 Sixteenth Street, N.W., Washington, D.C."
3. *Science and Engineering of Nuclear Power*, C. Goodman, Editor, Addison-Wesley Press, Cambridge, (1947); "this book is at the college graduate level for the most part but will prove to be a useful reference book for some special purposes."
4. *Proceedings of the Conference on Nuclear Chemistry*, mimeographed record of a conference held in May 1947 at McMaster University, Hamilton, Canada, "an excellent introduction to nuclear chemistry. Copies may be obtained for $2.00 by writing the Chemical Institute of Canada, 18 Rideau St., Ottawa."
5. *The Bulletin of Atomic Scientists*, E. Rabinowitch and H. H. Goldsmith, Editors, published by the Atomic Scientists of Chicago, 1126 East 59th Street, Chicago, Illinois; "this very significant bulletin of the social and political implications of atomic energy and other developments of modern science should be in every high school library and available to every high school teacher."

During the afternoon session of the Eastern Association of Physics Teachers the following people demonstrated simple little devices and methods for use in the science classroom:

Mr. B. L. Cushing E. Boston High Sch.	The pendulum and the center of percussion.
Mr. J. T. Gibbons Brighton High Sch.	The mathematics of the hydraulic lift.
Mr. A. R. Clish Belmont High Sch.	Device to show visibly the tuning of a radio set. The falling chimney. A large permanent magnet, available from surplus government property.
Mr. H. F. Wiley Laconia, N.H. High Sch.	The falling body apparatus.
Mr. Carl Johnson North High Sch. Worcester	Apparatus to show the resolution of forces. Radio tube charge indicator.
Mr. W. R. Fletcher North High Sch. Worcester	The siphonoscope and the siphonometer. The sensitive flame, and method of making the jet. Resonant columns.

At the business session it was voted to send some books to a European University for the use of a student who made the request to the Eastern Association of Physics Teachers. These books are to be the property of the university but are to be used by the student so long as he is registered at the university. The members felt that this act may be one which will help make for greater understanding between the nations.

It was also voted to ask Mr. Albert R. Clish to act in the capacity of secretary in addition to his duties as the treasurer. Mr. Clish said that it was his hope that this change is not to be permanent for he wished the organization to keep the form as set forth by the founders. The Eastern Association of Physics Teachers is one of the oldest science teachers organizations in the country.

Respectfully submitted
ALBERT R. CLISH,
Secretary and Treasurer

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

Late Solutions

2059, 63, 4. *Paul Mount-Campbell, New Mexico Military Institute.*
2064. *Water Lyche.*
2067, 9. *S. E. Field, Ironwood, Mich.*
2065, 7, 9. *Hazel S. Wilson, Annapolis, Md.*
2055, 65, 6, 8. *C. W. Trigg, Los Angeles.*
2069. *Edward F. Baldyga, Bridgeport, Conn.*
2071. *Proposed by Grace E. Hicks, Austin, Texas.*

Show that

$$\sin\frac{2\pi}{7}+\sin\frac{4\pi}{7}+\sin\frac{8\pi}{7}=\frac{\sqrt{7}}{2}.$$

Solution by Norman Anning, Ann Arbor, Mich.

Let $7A=2\pi$. We wish to evaluate $\sin A+\sin 2A+\sin 4A$.
Put

$$R=\cos A+i\sin A.$$

Then

$$R \neq 1; \quad R^7 = 1; \quad \text{and}$$
$$R^6 + R^5 + R^4 + R^3 + R^2 + R + 1 = 0.$$

Let

$$S = R + R^2 + R^4.$$

Then

$$-1 - S = R^6 + R^5 + R^3.$$

And

$$\begin{aligned} -S - S^2 &= (R + R^2 + R^4)(R^6 + R^5 + R^3) \\ &= 1 + 1 + (1 + R + R^2 + R^3 + R^4 + R^5 + R^6) \\ &\quad 1 + 1 + 0 = 2. \end{aligned}$$

From $S^2 + S + 2 = 0$ it follows that

$$R + R^2 + R^4 = S = \frac{-1 \pm i\sqrt{7}}{2}.$$

From this, by equating real parts and imaginary parts, we have

$$\cos A + \cos 2A + \cos 4A = \frac{-1}{2},$$

$$\sin A + \sin 2A + \sin 4A = \frac{\pm\sqrt{7}}{2}.$$

That the plus sign must be chosen follows from the fact that

$$\sin A + \sin 2A + \sin 4A = \sin A + 2 \sin 3A \cos A$$

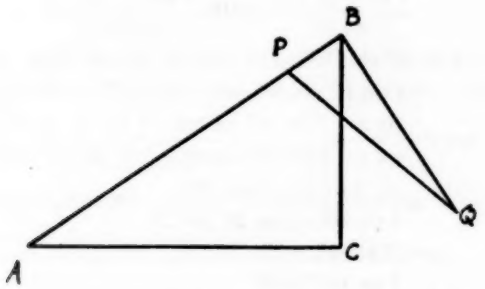
and all parts of the latter expression are easily seen to be positive.

Solutions were also offered by C. W. Trigg, Los Angeles City College; Francis L. Miksa, Aurora, Ill.; V. C. Bailey, Evansville, Ind.

2072. *Proposed by Hugo Brandt, University of Maryland.*

In a right triangle ABC, angle $C = 90°$, locate P on AB so that $AP = AC$. Also erect $BQ \perp BA$, with $BQ = BC$. Show that angle $PQB = \frac{1}{2}$ angle A.

Solution by Aaron Buchman, Buffalo, N. Y.



Using the usual notation for the sides of triangle ABC, it is evident that $PB = c - b$ and $BQ = a$.

Let angle $PQB = x$.

Since triangle PQB is a right triangle,

$$\tan x=\frac{c-b}{a}=\frac{1-(b/c)}{(a/c)}=\frac{1-\cos A}{\sin A}=\tan \tfrac{1}{2}A.$$

Therefore, $x=\frac{1}{2}A$

Note: Other solutions of the trigonometric equation $\tan x=\tan \frac{1}{2}A$ are impossible since both A and x are angles of triangles.

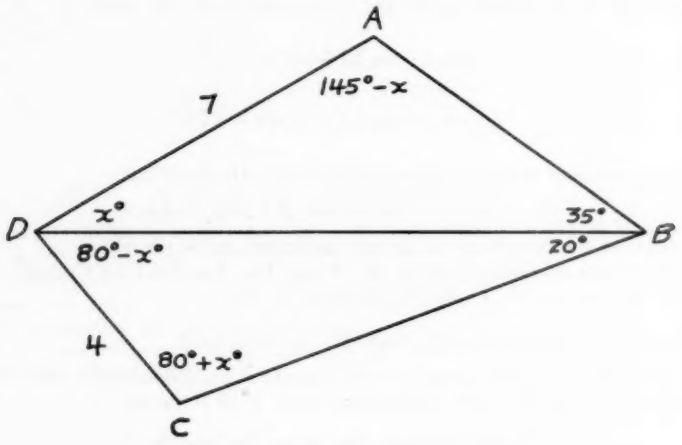
Other solutions were offered by Hugo Brandt, University of Maryland; C. W. Trigg, Los Angeles; Norma Sleight, Winnetka, Ill.; Walter L. Smith, Long Beach, Calif.; Francis L. Miksa, Aurora, Ill.; Robert E. Horton, Los Angeles; R. T. Ashbaugh, Longmont, Colo.; Felix John, Ammendale, Md.; Margaret Joseph, Milwaukee; Max Beberman, Nome, Alaska; V. C. Bailey, Evansville, Ind.

2073. *Proposed by W. W. Cherry, Berwyn, Illinois.*

Given quadrilateral $ABCD$ with diagonal BD. If $DC=4$, $DA=7$, angle $CDA=20°$, angle $ABD=35°$, find length of DB.

Solution by C. W. Trigg, Los Angeles City College

From the data, if $\angle ADB=x$, then $\angle BDC=80°-x$, $\angle BAD=145°-x$ and $\angle BCD=80°+x$. Then by the law of sines:



$$\frac{7\sin(145°-x)}{\sin 35°}=BD=\frac{4\sin(80°+x)}{\sin 20°}.$$

$$7\sin 20°\sin 145°\cos x-7\sin 20°\cos 145°\sin x$$
$$=4\sin 35°\sin 80°\cos x+4\sin 35°\cos 80°\sin x.$$

$$\tan x=\frac{\sin x}{\cos x}=\frac{7\sin 20°\sin 145°-4\sin 35°\sin 80°}{4\sin 35°\cos 80°+7\sin 20°\cos 145°}$$
$$=\frac{7\sin 20°-4\sin 80°}{4\cos 80°-7\sin 20°\cot 35°}=0.56712.$$

$$x=29°33'30''.$$

$$BD=\frac{7\sin 115°20°30''}{\sin 35°}\doteq 11.02.$$

Solutions were also offered by V. C. Bailey, Evansville, Ind.; Francis L. Miksa, Aurora, Ill.; Felix John, Ammendale, Md.; Paul Mount, Campbell, N. Mex. Military Institute; Norma Sleight, Winnetka, Ill.; and the Proposer.

2074. Something is wrong in the statement as given of this problem.

Charles W. Trigg, Max Beberman and Francis L. Miksa each gave an analysis to show an error.

2075. *Proposed by D. J. Newman, The Bronx, New York.*

Prove the identity:

$$\sin 1°+\sin 2°+\cdots+\sin 180°=\cot(\tfrac{1}{2})°.$$

Solution by Max Beberman, Nome, Alaska

Multiply and divide left member by sin 1°

$$(1)\qquad \frac{\sin 1°\sin 1°+\sin 1°\sin 2°+\cdots+\sin 1°\sin 180°}{\sin 1°}.$$

Using the relationship $\sin 1°\sin A=\cos 1°\cos a-\cos(1°+a)$ the numerator of (1) becomes:

$$(2)\quad \cos 1°\cos 1°+\cos 1°\cos 2°+\cdots+\cos 1°\cos 180°-\cos 2°-\cos 3°-\cdots-\cos 181°.$$

Collecting terms and factoring we have

$$(3)\quad \cos 1°(\cos 1°+\cos 2°+\cdots+\cos 180°)-(\cos 2°+\cos 3°+\cdots+\cos 180°-\cos 1°).$$

Since

$$\begin{aligned}&\cos\ 1°+\cos 179°=\cos\ 1°-\cos\ 1°=0\\&\cos\ 2°+\cos 178°=\cos\ 2°-\cos\ 2°=0\\&\cdots\cdots\cdots\cdots\cdots\\&\cos 89°+\cos\ 91°=\cos 89°-\cos 89°=0\end{aligned}$$

and

$$\cos 90°=0,\qquad \cos 180°=-1$$

then (3) becomes

$$(4)\qquad \cos 1°(-1)-(\cos 179°-1-\cos 1°)$$

or

$$(5)\qquad \cos 1°+1.$$

Hence (1) becomes

$$(6)\qquad \frac{\cos 1°+1}{\sin 1°}=\cot(\tfrac{1}{2})°.$$

Other solutions were offered by Paul Mount-Campbell, New Mexico Military Institute; V. C. Bailey, Evansville, Ind.; C. W. Trigg, Los Angeles; Francis L. Miksa, Aurora, Ill.

2076. *Proposed by Norman Anning, Univ. of Mich.*

Find the relationship which must exist among the angles A, B, and C in order that

$$\cos^2 A+\cos^2 B+\cos^2 C+2\cos A\cos B\cos C-1$$

may be zero.

Solution by Felix John, Ammendale Md.

1. Write the given expression as a quadratic equation in cos C:

$$\cos^2 C+2\cos A\cos B\cos C+(\cos^2 A+\cos^2 B-1)=0.$$

2. Solve this quadratic for cos C:
It is found that

$$\cos C = -\cos(A+B) \quad \text{and} \quad -\cos(A-B).$$

By symmetry

$$\cos A = -\cos(B+C) \quad \text{and} \quad -\cos(B-C)$$
$$\cos B = -\cos(A+C) \quad \text{and} \quad -\cos(A-C).$$

Hence

$$A \pm B \pm C = (2n+1)\pi.$$

Mr. Anning refers to Isaac Todhunter's *Plane Trigonometry*, from which the problem was taken. The given expression by elementary means reduces to

$$4\cos\frac{A+B+C}{2}\cos\frac{B+C-A}{2}\cos\frac{C+A-B}{2}\cos\frac{A+B-C}{2}.$$

The author comments, "One of the four compound angles must be some odd multiple of a right angle."

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2072. *Howard Bowen and Janet Hansen, New Trier H. S., Winnetka, Ill.*

PROBLEMS FOR SOLUTION

2089. *Proposed by V. C. Bailey, Evansville, Ind.*

Sides of a triangle a and b are 6 and 8 respectively. Find side c if the angle between h_c and m_c is 30°.

2090. *Proposed by Hugo Brandt, University of Maryland.*

Resolve into factors:

$$5a^4 - 6ab(2a^2 - 5ab + 2b^2) + 5b^4.$$

2091. *Proposed by Gloria Dover, Syracuse, New York.*

If the sides of a quadrilateral are 4, 5, 8, 9, and one diagonal is 9, find the area.

2092. *Proposed by Felix John, Ammendale, Md.*

In the quadrilateral $ABCD$, AB, BC, CD, DA, and AC equal 9, 12, 14, 13, and 15 respectively. Find BD.

2093. *Proposed by Charles Reade, Romulus, New York.*

Eliminate x, y, z from the equations

$$x^{-1} + y^{-1} + z^{-1} = a^{-1}$$
$$x + y + z = b$$
$$x^2 + y^2 + z^2 = c^2$$
$$x^3 + y^3 + z^3 = d^3.$$

2094. *Proposed by W. R. Warne, Alton, Illinois.*

Solve the system

$$\frac{\sqrt{x+a}-\sqrt{y-a}=\frac{5\sqrt{a}}{2}}{\sqrt{x-a}+\sqrt{y+a}\quad\frac{3\sqrt{a}}{2}}$$

BOOKS AND PAMPHLETS RECEIVED

CHEMISTRY IN ACTION, by George M. Rawlins, *Professor of Chemistry, Austin Peay State College, Clarksville, Tennessee, and Formerly Head of the Department of Science, Public Schools of the District of Columbia, Divisions I–IX;* Alden H. Struble, *Teacher of Chemistry, Western High School, Washington, D. C.* Cloth. Pages vi+571. 16×23.5 cm. 1948. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $3.00.

CHEMISTRY, A COURSE FOR HIGH SCHOOLS, by John C. Hogg, A.M., M.A. *Chairman, Science Department, The Phillips Exeter Academy, Exeter, New Hampshire;* Otis E. Alley, Ph.D., *Head of Science Department, Winchester High School, Massachusetts;* and Charles L. Bickel, Ph.D., *Instructor in Science, The Phillips Academy, Exeter, New Hampshire.* Second Edition. Cloth. Pages x+555. 15×23 cm. 1948. D. Van Nostrand Company, Inc., 250 Fourth Avenue. New York, N. Y. Price $2.88.

COMMERCIAL ARITHMETIC, A TEXT FOR STUDENTS IN THE BUSINESS OR GENERAL COURSE, by Virgil S. Mallory, *Professor of Mathematics and Teacher in the Demonstration School, State Teachers College, Montclair, New Jersey;* William M. Polishook, *Associate Professor and Director of Business Education, Temple University;* Ivan E. Chapman, *First Assistant Superintendent, Public Schools, Detroit, Michigan;* and S. Herbert Starkey, Jr., *Head, Mathematics Department, High School, Madison, New Jersey.* Cloth. Pages vii+510. 13.5×20.5 cm. 1948. Benj. H. Sanborn and Company, 221 East 20th Street, Chicago 16, Ill. Price $1.96.

PREPARING FOR FEDERAL RADIO OPERATOR EXAMINATIONS, by Arnold Shostak, B.S. in Eng., E.E., *Formerly U. S. Radio Inspector, Federal Communications Commission; Member, Institute of Radio Engineers; Lieutenant Commander, U.S.N.R.* Cloth. Pages xi+404. 12.5×18.5 cm. 1948. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $3.75.

BROADCAST OPERATORS HANDBOOK, by Harold E. Ennes, *Staff Engineer at Station WIRE in Indianapolis, Indiana.* Cloth. Pages xiii+265. 13.5×21.5 cm. 1947. John F. Rider, Inc., 404 Fourth Avenue, New York 16, N. Y. Price $3.30.

NATURE QUESTS AND QUIZZES, A NATURE SEEKER'S HANDBOOK, by Raymond Tifft Fuller. Cloth. 64 pages. 12×19 cm. 1948. The John Day Company Inc., 2 West 45th Street, New York, N. Y. Price $1.50.

FUNDAMENTALS OF BUSINESS MATHEMATICS, by Walter R. Van Voorhis. Ph.D., *Associate Professor of Mathematics, Fenn College,* and Chester W. Topp. M.A., *Assistant Professor of Mathematics, Fenn College.* Cloth. Pages viii+454, 13×20.5 cm. 1948. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $3.75.

INTEGRATION IN FINITE TERMS, by Joseph Fels Ritt, *Davies Professor of Mathematics, Columbia University.* Cloth. Pages viii+100. 13.5×21.5cm. 1948. Columbia University Press, Morningside Heights, New York 27, N. Y. Price $2.75.

MODERN-SCHOOL GEOMETRY, by John R. Clark, *Professor of Education, Teachers College, Columbia University;* and Rolland R. Smith, *Coördinator of Mathematics, Public Schools, Springfield, Massachusetts;* with the Coöperation of

Raleigh Schorling, *Head of Department of Mathematics, The University High School, and Professor of Education, University of Michigan.* New Edition. Cloth, Pages xii+436. 13×20.5 cm. 1948. World Book Company, Yonkers-on-Hudson. New York. Price $1.88.

A First Course in Algebra, by Walter W. Hart, *Author of Mathematics Textbooks, Formerly Associate Professor of Mathematics, School of Education, University of Wisconsin.* Cloth. Pages viii+389. 13.5×20.5 cm. 1947. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price. $1.76.

A Second Course in Algebra, by Walter W. Hart, *Author of Mathematics Textbooks, Formerly Associate Professor of Mathematics, School of Education, University of Wisconsin.* Cloth. Pages ix+373. 13.5×20.5 cm. 1947. D.C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $1.76.

The Radio Amateur's Handbook, by Headquarters Staff of The American Radio Relay League. 25th Edition, 1948. Paper. 760 pages. 16.5×24 cm. The American Relay League, West Hartford 7, Conn. Price, $2.00 in the United States, its Possessions and Canada; $2.50 elsewhere.

Physical Science Made Easy, Questions, Answers, and Definitions, by Theodore G. Phillips, *Department of Physical Sciences, Chicago City Colleges, Lecturer in Physical Sciences, Roosevelt College of Chicago;* and William Colburn *Department of Physical Sciences, Roosevelt College of Chicago.* Paper. 346 pages. 14.5×22 cm. 1948.

FM Transmission and Reception, by John F. Rider, and Seymour D. Uslan Paper. 416 pages. 13.5×21 cm. John F. Rider, Publisher, Inc., 404 Fourth Avenue, New York 16, N. Y. Price, Paper $1.80; Cloth $2.70.

Guidance Pamphlet in Mathematics for High School Students. Final Report of the Commission on Post-War Plans of The National Council of Teachers of Mathematics. November 1947. 25 pages. 17.5×26 cm. The National Council of Teachers of Mathematics, 525 West 120th Street, New York 27, N. Y.

Our Heritage, by W. W. Livengood, *Editor-in-Chief and Vice President, American Book Company.* Paper. 32 pages. 15×22.5 cm. American Book Company, 88 Lexington Avenue, New York, N. Y.

Still Unfinished Our Educational Obligation to America's Children. Report of a study Conducted by the Institute of Administrative Research, Teachers College, Columbia University. Paper. 32 pages. 21.5×28 cm. 1948. National Education Association of the United States, Legislative-Federal Relations Division, 1201 Sixteenth Street, N.W., Washington 6, D. C.

Speaking to Youth, by F. J. Davis, *Principal, du Pont Manual Training High School, Louisville, Kentucky,* and George Stoll, *President, Stoll Oil Refining Company, Louisville, Kentucky.* Paper. 41 pages. 10×22.5 cm. 1946. Paul's Workshop, Inc., 241 East Walnut Street, Louisville, Ky. Price 25 cents.

BOOK REVIEWS

Advanced Calculus by David V. Widder, *Professor of Mathematics, Harvard University.* Cloth. Pages xvi+432. 16×23.5 cm. Prentice-Hall, Inc. New York. 1947. Price $5.00.

The contents of books entitled Advanced Calculus probably vary more than almost any other subject in mathematics. This particular text is planned for the student who has completed three to four semesters of work in more elementary

calculus. The treatment progresses through manipulative problems into and through more advanced theory.

About seventy-five pages are devoted to partial differentiation and applications. There are chapters on differential geometry, the Stieltjes integral, the Gamma function, Fourier's series, and two chapters on the La Place transformation and its applications, in addition to material common to most texts in advanced calculus. As a result more material is included than could normally be included in a year course.

The treatment is quite rigorous and the book, if not suitable for a text in a particular course, should be available for reference in the library. The number of problems is relatively small but offers sufficient material to challenge the student. Anyone opening the book at random will discover that it takes a little time to become familiar with the particular notation used, but the notation does result in a marked brevity and conciseness of statement.

CECIL B. READ
University of Wichita

ANALYTIC GEOMETRY, by David S. Nathan, Ph.D., *Department of Mathematics, College of the City of New York*, and Olaf Helmer, Dr. Phil., Phd., *Research Mathematician, Douglas Aircraft Company*. Cloth. Pages x+402. 16×23.5 cm. Prentice-Hall, Inc. New York. 1947. Price $3.50.

This text offers a more extensive treatment than is found in many books. Subjects which are treated in this manner include curve sketching, loci in polar coordinates, discussion of curves given in parametric equations. The text includes quite extensive treatment of some elementary concepts, for example, straight lines and angles, trigonometric functions, and functional notation. The treatment of the ellipse and hyperbola is from the point of view of a definition in terms of focus, directrix, and eccentricity, the definitions in terms of sums or differences of distances from two foci appearing only as illustrative problems.

Tangents and normals are treated only incidentally in a problem. A somewhat unusual feature is the discussion of the general locus in space before treating planes and lines. There is no use of determinants in the book. Figure 159 contains an obvious error. There seems to be an ample supply of problems, with answers to the odd numbered exercises. Formulas and tables sufficient to work most of the problems in the book are included.

Whether or not the text is suitable for a particular course depends upon the extent of coverage desired. In some colleges all of the material could not be included in a one-semester course.

CECIL B. READ

CHEMICAL CALCULATIONS, Revised Edition, by Bernard Jaffe, *Chairman of the Department of Physical Sciences, James Madison High School, Brooklyn, New York*. Cloth, Pages xxii+180, 12×19 cm., 1947, World Book Company, Chicago, Illinois. Price $1.60.

This volume is a systematic presentation of the solution of type problems in chemistry. There are 1000 chemical problems arranged progressively according to lesson assignments.

This volume furnishes the teacher the means of vitalizing and strengthening her presentation of mathematical problems in chemistry. This has been a much needed type of publication, for the usual book in the field tends to under emphasize this important phase of the work. The book is so designed that it can be used with most of the recent textbooks in the field.

The first part of the book describes ten types of problems. The method of solving each type is clearly explained and numerous examples for practice are given as each new step is presented. Part II illustrates and explains more advanced problems such as those based on the theory of ionization. Part III has 53 types of problems based on lesson assignments, with the principal equations under

each topic. A useful appendix is furnished for use with the problems.

It is my opinion that the book will enable the teacher to strengthen the weakness of students in the mathematics of elementary chemistry.

KENNETH E. ANDERSON

CONCISE CHEMICAL AND TECHINICAL DICTIONARY, Edited by H. Bennett, *Technical Director, Glyco Products, Inc.* Cloth. Pages xxxix+1055, 15×23 cm., 1947, Chemical Rubber Company, Inc., Brooklyn 2, N. Y. Price $10.00.

This is a much needed dictionary—one designed for both the professionals and laymen. About 50,000 definitions are included in the volume covering terms on chemistry, metallurgy, pharmacy, plastics, mineralogy, electricity, engineering, bacteriology, physics, botany, biology, trade name products, mathematics, textiles, medicine, and industry.

The dictionary is unique in that it has an up-to-date compilation of trade-name or proprietary products. The chemical and physical properties, the applications of the trade-name product, and its chemical composition are described. For example: "Velsicol. Commercial mixture of polymethylated naphthalenes; used as solvent for DDT and other insecticides."

The front of the dictionary contains a section giving directions for use of the dictionary, a section on the nomenclature of organic chemistry, a section on names and formulae of radicals occurring in organic compounds, and a section on the pronunciation of chemical words.

In the rear of the book, one will find useful sections on the Greek Alphabet; Mathematical Symbols; Metric Weights and Measures; Apothecary Symbols; U. S. Weights and Measures; Roughly Equivalent Measures; Chemical Elements and Their Discoverers; Temperature Conversion Scales; Indicators; Equivalents of Twaddell, Baume and Specific Gravity Scales; Vitamin Values of Important Foodstuffs; Important Organic Ring Systems; and an addenda on the newest trade names and definitions of additional technical terms.

Here is an indispensable reference for workers in every technical field. The layman will find it useful as an encyclopedia of knowledge.

KENNETH E. ANDERSON

AN INTRODUCTION TO PERSONAL HYGIENE, by Laurence B. Chenoweth, *University of Cincinnati.* Cloth. Pages xix+345. 13.5×20.5 cm. 1047. F. S. Crofts and Company, 101 Fifth Avenue, New York, N. Y. Price $2.50.

This textbook has been written for college students. The author has presented his material in a more scholarly manner and style than one expects to find in a book of this nature. The book is not only an introduction to modern personal hygiene but an excellent survey of this expanding science. Certainly the inquisitive layman would find it interesting reading. High School teachers of biological science will appreciate it as a useful reference.

Among the 17 chapters, the three on "Alcohol," "Mental Abnormalities," and "Mental Hygiene" will prove to be especially valuable to the student. There are six chapters that bring forth the latest findings concerning nutrition. The Chapter on "Cancer" is comparatively short but the author has undoubtedly used good judgment in this respect. The chapter on "Heredity" includes an account of the Rh factor.

The introductory chapter consists of a 42-page historical survey of health and disease through the ages. There are some readers, however, such as this reviewer, who will not be willing to accept certain statements in the author's historical sketch: for example, words to the effect that the Early Christian Church "finally accepted . . . soothsayings and astrology," and considered the human body as "of no importance . . . unworthy of study." This latter idea has been prevalent for many years probably because the early Christians placed such a comparatively greater emphasis on man's spiritual welfare in contrast to the pagan's chief concern for his physical being.

Considering this textbook as a whole, the author is to be complimented on his worthwhile contribution in meeting the needs for a book of this type.

JOSEPH P. MCMENAMIN

OUR NEIGHBORS AT HOME, by J. Russell Smith, Ph.D., Sc.D., *formerly Professor of Economic Geography, Columbia University* and Frank E. Sorenson, Ph.D., *Associate Professor of Education, University of Nebraska.* Cloth. Pages vi+250, 26×20.5 cm. 274 illustrations. 1947. The John C. Winston Company, Philadelphia 7, Pa. Price $1.92.

This Third Grade text is the first in the new *Our Neighbors Series.* It is attractively illustrated with excellent photographs and many interesting sketches in color. It acquaints the child with eleven different communities, introducing him to children in each community and making him a partner in their work and play. Through many interesting experiences he finds that people depend upon each other, and that communities are interdependent. He finds that what people do, and how they do it depends upon where they live.

Excellent bibliographies distributed through the text provide guidance in the selection of supplementary reading material. Frequent questions, check-up exercises and suggestions for things to do furnish active learning situations. The final exercise furnishes eleven well chosen photographs and an opportunity to use them in summarizing the year's work.

VILLA B. SMITH
John Hay High School
Cleveland, Ohio

NEIGHBORS AROUND THE WORLD, by Russell Smith, Ph.D., Sc.D., *formerly Professor of Economic Geography, Columbia University* and Frank E. Sorenson, Ph.D., *Associate Professor of Education, University of Nebraska.* Cloth. Pages viii+309. 26×20.5 cm. 309 illustrations, — maps, photographs and sketches. 1947. The John C. Winston Company, Philadelphia 7, Pa. Price $2.16.

This Fourth Grade text, in the new *Our Neighbors Series,* contains twenty-eight chapters organized in eleven units. The initial unit introduces the world through a series of globe maps and acquaints the pupil with continents and oceans, with northern, southern, eastern and western hemispheres, with north pole, south pole and equator, with direction and ways of telling it, with earth rotation and consequent day and night.

The following ten units build a world understanding through the consideration of life in various climatic zones from polar to equatorial regions. Since climatic areas occur in east-west strips around the earth, and since strips are similar in northern and southern hemispheres, each unit acquaints the child with life in widely scattered areas.

The text is illustrated with numerous interesting photographs and many full page colored sketches. All units have special globe maps showing the location of the areas under discussion. Sketches furnish an interesting summary exercise for each unit. Frequent short quizzes and suggestions for things to do, direct pupil activity. Bibliographies furnish supplementary reading lists.

VILLA B. SMITH

SECONDARY-SCHOOL SCIENCE TEACHING, by Arthur G. Hoff, Ph.D., *Associate Professor of Education, University of Redlands, Redlands, California.* Cloth. Pages XI+303. 15×21 cm. 1947. The Blakiston Co., Philadelphia, Price $3.50.

The purpose of this text is well described by the author's statement, " . . . to give the science teacher guidance on the total area of teaching." Such a purpose is admirable, since most methodologies fail to give due consideration to the position of particular subject-matter fields in the total curriculum, or to the associated duties and responsibilities of the teacher in fields other than his own.

The attempt, however, to cover such a wealth of material has frequently resulted in a somewhat vague organization, and in a cursory coverage of the material presented. It would be necessary for the student to do considerable supplementary reading in order to obtain an adequate understanding of the various phases of science teaching presented in this text.

The author has digested a tremendous number of committee reports, articles, bulletins and studies on science teaching, but the date of preparation of material for publication is unfortunate, since it antedates the appearance of the Forty-sixth Yearbook of the National Society for the Study of Education, the Sponsor's Handbook of the Science Clubs of America, the published reports of the Wise and Martin studies on science principles and the tests of the Progressive Education Association. This is responsible for the absence of much up-to-date science education material, since earlier publications in these areas are cited.

The lack of illustrative material, the presence of editorial errors, such as "five books on sociology, comprising fifty thousand pages of material," the appearance of sample test items in three separate places, also detract from the merit of this book.

Despite the mentioned weaknesses the book certainly is a worth while addition to the library of the science teacher, since the vast amount of material for science teaching which is presented certainly would suggest topics for further study and source references for greater exploration.

GEORGE G. MALLINSON
Iowa State Teachers College
Cedar Falls, Iowa

SURVEYING INSTRUMENTS, THEIR HISTORY AND CLASSROOM USE, by Edmond R Kiely. Cloth. Pages xiii + 411. 15 × 23 cm. 1947. Bureau of Publications, Teachers College, Columbia University, New York. Price $3.00.

This is the Nineteenth Yearbook of the National Council of Teachers of Mathematics, edited by W. D. Reeve. The first 235 pages are largely devoted to a history of the development and use of surveying instruments of all kinds. Many illustrations are included, some of which are photographs of the actual instruments, others contemporary prints indicating how they were employed.

The first two short chapters trace the beginnings of the subject in Egypt, China and Babylonia, and in Greece and Rome. The two succeeding chapters are much more extensive. They discuss the contributions of medieval Europe, Islam and India, and advancements in Europe during the Renaissance.

Chapter V points out that the classroom use of such instruments as have been described would be of a great benefit in the teaching of geometry. The author states his reasons thus. "First, our simplifications naturally lead us back to [the old instruments; they] were simple in construction, and the complications of the astrolabe and quadrant arose from their connections with astronomy and astrology and have no significance in surveying. Second, the geometric significance of any operation is plainly visible on the instruments themselves; they contain no hidden parts to interfere with the young student's analyzing for himself just exactly what is going on during any given operation. Third, they fulfill the need of ease in manipulation. Lastly, the old instruments are intimately connected with the history of practical measurement, and no course which pretends to give an outline of this history can afford to ignore them."

An extensive series of exercises in the application of geometry and trigonometry in simple surveying is included. Directions are concise but complete; the instruments required are of the simplest. At least some of these exercises, taking the student out of the classroom and applying directly what he has there learned, would be valuable aids in vivifying the traditional drawing of diagrams.

The book concludes with an appendix in which are quoted some of the sources that have been drawn on, and a very extensive bibliography. It should be stimulating to any teacher of geometry or trigonometry, and a reference work to arouse the interest of all students.

JOSEPH D. ELDER

PHYSICS FOR STUDENTS OF SCIENCE AND ENGINEERING, by William H. Michener, *Assistant Professor of Physics, Carnegie Institute of Technology*. Cloth. Pages x+646. 13.5×21 cm. 1947. John Wiley and Sons, Inc., 440 4th Ave., New York 16, New York. Price $4.25.

As the title indicates, this textbook is designed for students who study physics because they intend to use it as a tool in later work. Yet because of the clarity of the writing, the accuracy of definitions and the completeness of treatment the book could be used for a liberal arts course, although applications of principles are chosen chiefly from engineering sciences. It would be of value as a reference work for the student in such a course who wants to know more about a particular topic.

The book follows the usual division of subject matter; mechanics, heat, wave motion and sound, light, electricity. Topics that are frequently called "modern physics" are included in the last chapter.

A noteworthy advantage of this textbook is its consistent, though not exclusive, use of the mks system of units. The British engineering system is of course necessary, particularly in mechanics, and the cgs system is introduced as well. The calorie and the Btu are given as the units of heat. But the bulk of the work is done in the mks system, which is surely the one best adapted for use in electricity, and the one that should be adopted as basic in all future textbooks. A careful distinction is made between mass and weight, and the names of the units of mass and of force are clearly differentiated.

Problems are grouped together at the end of the book. Answers are given for perhaps two-thirds of them. The book assumes a more extensive training in mathematics than some students will have, but not too much to expect of sophomores who intend to major in science. The notation of the calculus is introduced very early, and the methods of calculus are used later on where they introduce simplicity or completeness in the solution of problems or derivation of equations.

Almost all historical material has been omitted, obviously for the sake of brevity. It is unfortunate that the student who is primarily preparing for a career in science or engineering should not have at least enough historical background in his science that he can relate the major achievements in it to the times in which they were made. But perhaps it is too much to expect such a student to learn the science and the history at the same time.

This is a valuable textbook, one that appears to be eminently teachable and requiring no more than a decent effort on the part of the student for understanding.

JOSEPH D. ELDER

ESSENTIALS OF STRENGTH OF MATERIALS, by Torquato J. Pisani, *Teacher of Applied Mechanics, Brooklyn Technical High School, Brooklyn, New York*. Cloth. Pages vii+229. 15×23 cm. 1947. D. Van Nostrand Co., Inc. New York. Price $2.80.

The author of this textbook says in the preface that the book "is designed to present in a brief and systematic manner a text in elementary mechanics and strength of materials suitable for students in technical high schools and technical institutes and in the better vocational high schools. . . . To adapt the subject to the secondary level has necessitated a simpler and more thorough presentation" than that of college textbooks in the field, which usually require calculus.

In the first paragraph, work is defined as "the overcoming of resistance through a distance." As examples, the hydraulic jack, pulleys, and other simple machines are cited. But beams are included, and a beam does no work in the technical sense.

On page 2, in a discussion of the lever, the statement is made that "the amount of work accomplished is determined by multiplying the resistance or effort by its lever arm measured from the fulcrum to its outer end. This product is called a moment." The product may be the moment of a force, provided the force and the lever arm are at right angles, but it is certainly not work.

In the list of problems on the lever, it is uniformly assumed, but not stated, that the lever is horizontal and the forces vertical, moreover, in all but one of the problems the weight of the lever is either explicitly or implicitly neglected. The exception is the following. "A 2 in. $\times$ 4 in. stud 10 ft. long has a load of 50 lbs. suspended from one end and is balanced when a support is placed 3 ft. from that end. What does the stud weigh?" How is the student going to solve this problem when there has been no mention of the concept of center of gravity?

Again, one finds the statement, "the modulus of elasticity of a body is a measure of its stiffness or rigidity," although from the use made of it, it is evidently Young's modulus that is meant.

There is a general confusion between force and stress. Thus, "the total force, or end pressure," on a boiler is $p\pi r^2$, and "the total pressure P exerted on any diametrical plane is pLd," p being the "pressure in psi. exerted normally to the surface of the container, L the length of the pipe and d the diameter of the pipe or container."

The English used in the book leaves something to be desired, as the following quotations indicate. "The resultant of two component forces is the diagonal of a parallelogram formed by two parallel lines drawn from the ends of the component forces. This is called the parallelogram of forces." "The rivets in a boiler shell . . . are examples of the effect produced by a shearing force or stress." "A steam locomotive is a good example of the pressure exerted on the inside of a boiler."

These examples are sufficient to show why the book cannot be recommended.

JOSEPH D. ELDER

A MATHEMATICS INSTITUTE AT WISCONSIN UNIVERSITY

An Institute for Mathematics Teachers, sponsored by the School of Education and the Department of Mathematics, will be held at the University of Wisconsin July 20–22, 1948. Professor Ralph Beatley, Harvard University; Mr. William Betz, Rochester, N. Y.; Miss Mary Potter, Racine, Wis.; Professor H. G. Ayre, Western Illinois State College; Professor Bjarne Ullsvik, Illinois State Normal University; and members of the University of Wisconsin faculty will address general sessions and lead discussion groups. In addition, many teachers of mathematics in Wisconsin secondary schools will appear on the program in panel discussions.

Among titles of scheduled addresses are: "The Impact of Mathematics on Method," "Teaching Mathematics into Its Rightful Place," "Does the Taxpayer Get His Money's Worth in Arithmetical Competence in a High School Graduate?" and "The Basic Significance of Mathematics."

The program includes group and panel discussions on such topics as: two-track program in mathematics, basic concepts in algebra and geometry, elements of a functional program in mathematics, guidance in mathematics, measurement of understanding, the textbook, classroom and equipment, field work, the accelerated student, a 12th grade class for students deficient in essentials, interesting stories for motivation, statistical concepts, classes for the slow learner, and making percentage meaningful.

An exhibit of classroom materials prepared by students, demonstration of visual aids, and a visit to the U. S. Forest Products Laboratory and University Engineering Laboratories are also planned.

Rooms will be available in one of the University dormitories. For information or reservations, write to J. R. Mayor, North Hall, University of Wisconsin, Madison.